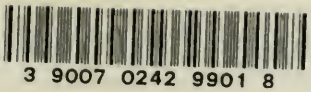

Ontario Research Commission

INTERIM REPORT

FEBRUARY
1947

PRINTED BY ORDER OF
THE LEGISLATIVE ASSEMBLY OF ONTARIO
SESSIONAL PAPER No. 47, 1947

ONTARIO

TORONTO
Printed and Published by H. E. Brown
Acting Printer to the King's Most Excellent Majesty

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To The Hon. Ray Lawson, O.B.E.,

Lieutenant-Governor of the Province of Ontario.

May It Please Your Honour:

The undersigned has the honour to present to your Honour the Interim Report of the Ontario Research Commission.

Respectfully submitted,

D. R, Michener.
Provincial Secretary.

Department of the Provincial Secretary.
February 6th, 1947.

December 4th, 1946

The Honourable D. R. Michener,
Provincial Secretary,
Province of Ontario,
Toronto, Ontario.

Dear Mr. Michener:

It is my privilege to transmit herewith a report of progress of the Ontario Research Commission, pursuant to Order-in-Council dated August 28th, 1945.

I have the honour to be, sir,

Your obedient servant,

R. C. Wallace,
Chairman.

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TERMS OF REFERENCE

ONTARIO

EXECUTIVE COUNCIL OFFICE

Copy of an Order-in-Council approved by the Honourable, the Lieutenant-Governor, dated the 28th day of August, A.D. 1945.

Upon the recommendation of the Honourable the Prime Minister, the Committee of Council advise that pursuant to the provisions of The Public Inquiries Act, R.S.O. 1937, chapter 19,

Dr. R. C. Wallace	E. Holt Gurney	Dr. Sidney Smith
W. E. Phillips	Dr. R. K. Stratford	Dr. G. I. Christie
H. M. Turner	Dean C. R. Young	Dr. T. H. Hogg

Dr. C. E. Burke, and Dr. W. Sherwood Fox

be appointed commissioners to inquire into and report upon all matters concerned with scientific and industrial research as they affect the Province of Ontario and in particular to inquire into and report upon,

(a) any matter relating to the utilizing of scientific personnel and scientific facilities;

(b) any application or request to the Government of Ontario for financial support for any project within the field of industrial and scientific research;

(c) the co-ordination of the activities of existing and prospective research units which are supported in whole or in part by public funds; and

(d) the integration of research activities within the Province of Ontario with research activities outside the Province of Ontario.

The Committee further advise that Dr. R. C. Wallace be appointed chairman of the Commission and that Professor J. O. Wilhelm be appointed Secretary of the Commission.

And the Committee further advise that the said Commissioners shall have the power to summon any person and require him to give evidence on oath and to produce such documents and things as the commissioners deem requisite for the full investigation of the matters into which they are appointed to examine, by subpoena signed by the chairman or by any one of the commissioners hereby appointed.

Certified.

"C. F. Bulmer,"
Clerk, Executive Council.

ONTARIO

EXECUTIVE COUNCIL OFFICE

Copy of an Order-in-Council approved by The Honourable the Lieutenant-Governor, dated the 23rd day of July, A.D. 1946.

The Committee of Council have had under consideration the report of the Honourable the Provincial Secretary, dated July 18th, 1946, wherein he states that.—

WHEREAS, under the provisions of The Public Inquiries Act, a Commission under the Great Seal bearing date the twenth-eighth day of August, 1945, appointed Dr. R. C. Wallace et al to inquire into and report upon

(a) any matter relating to the utilizing of scientific personnel and scientific facilities;

(b) any application or request to the Government of Ontario for financial support for any project within the field of industrial and scientific research;

(c) the co-ordination of the activities of existing and prospective research units which are supported in whole or in part by public funds; and

(d) the integration of research activities within the Province of Ontario with research activities outside the Province of Ontario;

AND WHEREAS it is deemed expedient that E. T. Sterne of the City of Brantford should be associated in the said inquiry;

The Honourable the Provincial Secretary therefore recommends that, pursuant to the provisions of the said The Public Inquiries Act, the said E. T. Sterne be appointed a Commissioner for the purposes in the aforesaid Commission contained and recited to be associated for that purpose with the Commissioners therein named, fully and effectually giving and granting unto the said E. T. Sterne all and every the like powers given and granted by the said Commission to the said Commissioners as if the said E. T. Sterne had been appointed by the Commission aforesaid.

The Committee of Council concur in the recommendation of the Honourable the Provincial Secretary, and advise that the same be acted upon.

"C. F. BULMER,"
Clerk, Executive Council.

Appointments

The Ontario Research Commission was appointed by Order-in-Council dated August 28th, 1945, under authority conferred by The Public Inquiries Act, R.S.O. 1937, Chapter 19. The Commissioners appointed were—

Dr. R. C. Wallace, Chairman

Mr. E. Holt Gurney	Dr. Sidney Smith	Mr. W. E. Phillips
Dr. R. K. Stratford	Dr. G. I. Christie	Mr. H. M. Turner
Dr. C. R. Young	Dr. T. H. Hogg	Dr. C. E. Burke
	Dr. W. Sherwood Fox	

Owing to the prolonged illness of Dr. Christie, **Mr. W. R. Reek** was asked to act during his absence. The Commissioners wish to express their appreciation of the services he has rendered. By Order-in-Council dated July 23rd, 1946, **Mr. E. T. Sterne** was appointed to the Commission. The appointment of Mr. Sterne was welcomed by the original Commissioners because, aside from the personal contributions Mr. Sterne has made, he represents to the Commission the viewpoint of smaller industries.

The Order-in-Council of August 28th, 1945, appointed Professor J. O. Wilhelm as Secretary of the Commission. His appointment was made possible by an arrangement with the Physics Department of the University of Toronto, On October 2nd, 1945, by Order-in-Council, Miss K. Huff was appointed Secretarial Stenographer.

Accommodation

The Commission has been housed in two offices generously provided by the Ontario Research Foundation at 43 Queen's Park. Facilities for the Commission and Committee meetings have been provided by the Ontario Research Foundation, the University of Toronto, the Ontario Agricultural College, Queen's University, the Horticultural Experimental Station (Vineland), and the Provincial Parliament Buildings. The thirteenth and fourteenth meetings of the Commission were held at Niagara Falls.

The Task

The Order-in-Council appointing the Commission imposed on it, either expressly or by implication, the task of inquiring into and reporting on the conditions pertaining to scientific personnel and scientific facilities, on the possibilities of co-ordination and integration of research work in the Province, and on the role the Government of the Province might assume in any overall programme of research. The task assigned involved the investigation of the work done and being done by the various research agencies, both public and private, together with consideration of the programmes planned by each, with a view to making recommendations for the possible direction of their efforts into channels which will eliminate any danger, real or imaginary, of duplication of effort.

The Method

Accepting the thesis that it should play the role of advisor and co-ordinator only, and not an instrument of research in itself, the Commission adopted the policy of setting up Advisory Committees, each committee consisting of repre-

sentatives of groups or institutions vitally concerned in a particular field. The usual procedure was to invite such representatives to a conference at which one of the Commissioners and the Secretary were present. The Commissioner acted as chairman, and outlined to those present the purpose of the Commission, inviting their co-operation in the achievement of its aim. Each group was encouraged to elect its own chairman, and to function, with the help of the Commission in Secretarial and financial matters, as an independent unit. The members were invited to suggest others for membership on the Committee,and each was encouraged to submit to the group the plans and needs of the organization which he served. It was the duty of the Committee, when all available information was at hand, to co-ordinate the whole, and submit to the Commission a complete report of its findings and its recommendations. In the case of Forestry, where the whole field was readily divisible into the phases of Production and of Utilization, sub-committees were formed to consider each phase, and, following their submissions, a joint session provided an opportunity for consideration of the whole problem. Whenever possible, the Commissioners attended meetings of the advisory committees, in order that they might have a clearer understanding of all the factors. The task of the Commission has been made much easier and much happier by the splendid spirit of co-operation displayed by the various groups with which it has worked. That spirit is, of course, merely an extension of the amicable relationships which have been built up over a period of years among those groups concerned with research.

Commission Meetings

The following is a schedule of the meetings held by the Commission during the past year—

September 10th, 1945	Ontario Research Foundation
October 15th, 1945	Ontario Research Foundation
November 14th, 1945	Ontario Research Foundation
December 10th, 1945	Ontario Research Foundation
January 17th, 1946	Ontario Research Foundation
February 13th, 1946	Simcoe Hall, University of Toronto
March 6th, 1946	Simcoe Hall, University of Toronto
April 17th, 1946	Simcoe Hall, University of Toronto
May 8th, 1946	Simcoe Hall, University of Toronto
June 19th, 1946	Simcoe Hall, University of Toronto
July 11th, 1946	Ontario Agricultural College
**September 18th, 1946	Ontario Research Foundation
October 12th-14th, 1946	Niagara Falls
November 30th-December 1st, 1946	Niagara Falls
December 11th, 1946	Ontario Research Foundation
December 11th, 1946 (with Cabinet Committee)	Provincial Parliament Buildings
January 15th, 1947	Simcoe Hall, University of Toronto

**Preliminary Industrial Research meeting.

Research is proving to be the basis on which sound progress is being made in the expansion of industry and in the development of natural resources. In this Province the responsibility for research is assumed partly by the government and partly by industry, the universities, the Ontario Research Foundation and other agencies. At present, because of a shortage of trained personnel and facilities for research, any budget for a programme of expansion will have to be small in the beginning, increasing progressively as conditions permit. Moreover, in order to develop research teams on the most efficient basis, continuity must be ensured for a large part of the programme. This means not only that one must expect moderate expenditures at once, but also that, in some cases, financial provision must be made on a long-term basis.

Since the development and extension of research in Ontario is vitally dependent upon the availability of trained personnel, the Commission would recommend that the Department of Education, the universities, the technical institutions, and the industry of the Province promote and expedite in every possible way the training of persons who can give useful assistance in this field.

The Commission wishes to emphasize the fact that senior members of the staffs of universities have very heavy teaching duties because of the unusually large registration of students that now obtains. They are unable to give adequate time to the training of graduate students in research. With additional finanical assistance the universities would be able to add suitable men to their staffs in order to meet this need. Action of this kind would produce very valuable results by increasing the number of young scientists urgently required to undertake research both in pure and in applied science. The Treasury grants to the British universities are being greatly increased for the purpose of accelerating the training of skilled research workers.

The Ontario Research Commission is of the opinion that an important contribution to the desired end may be made by furthering the training of technicians in courses of the technical institute type, courses that extend over a period of one or two years and are of a grade lying between that of the vocational high schools and that of the universities. The assistance of an adequate number of persons trained in such courses would approximately double the effectiveness of the present appallingly small number of qualified research workers who have been trained in the universities.

At the same time, the Commission desires to commend in general the longer and more advanced programmes of educational training in industry as productive of persons valuable to research. It is to be hoped that industry will be able to extend this service.

Though the provision of certain research facilities and the maintenance of interest in research is one of the functions of university departments, the Commission feels that assistance to students by way of scholarships and assistance to the universities in the carrying out of specific research projects will be a major factor in promoting the training of research workers and in the actual development of basic research. To further this purpose the Commission recommends that a sum of fifty thousand dollars ($50,000.00) be made available for scholarships, these to be granted to specially selected graduate students to assist them in securing their graduate training. In addition, through the medium of Advisory Committees in the fields of Agriculture, Fisheries and Wildlife, Forestry, Mines,

Minerals and Metallurgy, and Soils, the Commission is recommending specific projects for which support should be given. These projects are co-ordinated with the work being done by Dominion Government departments, Provincial Government departments, universities, industry and all such other agencies as are actively interested in the particular field concerned. The situation in regard to research in the various fields and the cost of the projects recommended are summarized in the appendices attached to this report.

The Commission is of the opinion that industry in the Province has to be much more adequately informed on the value of research and on the results of research which may be helpful to individual industries. The distribution of information of this kind may be effected by setting up a system of "extension" and the initiation of some form of co-operative effort in which the industries and government are jointly engaged. In the beginning government may be asked to assume a considerable proportion of the expense. As industry takes over more and more of the responsibility of the programme, it would be reasonable to expect that the government's share would be reduced. In Britain the government at present is carrying from 25% to 40% of the cost of the research which is being done by trade research associations.

The amount to be spent on research by any industry, government body, university, or foundation, is not easy to justify on an economic basis in terms that meet the requirements of boards of directors and treasury officials. General figures can, however, be given and from the comparison of such figures a reasonable guide may be found.

	Amount Spent	Year
CANADA		
Industry (280 firms)	$ 10,750,000	1944
National Research Council (not including war research)	6,378,000	1944
*Universities ($441,899 from N.R.C. on war research)	1,251,050	1944-45
U.S.A		
Industry	300,000,000	1940
BRITAIN		
Industry	25,000,000	1938
Research Associations	4,000,000	1943
Department of Scientific and Industrial Research (To the Universities of Britain for research)	45,000,000	1946
Sir Ernest Simon estimates (University expenditures for research)	125,000,000	1955

*Alberta, British Columbia, Manitoba, McMaster, Queen's, Saskatchewan, Toronto and Western Ontario.

It is obvious that if Ontario, representing as it does 40% of Canadian industrial potential, is to go forward and maintain its place in the markets of the world research facilities must be extended. To do this will require increasing sums of money for research and on a basis ensuring reasonable continuity to attract the best of our technical personnel into research fields. A factor which should also be borne in mind is the necessity of maintaining freedom of action for research groups in the selection of their research programmes.

The recommendations for Provincial support of research† which are made herewith, are strictly within the area of Provincial responsibility and are closely co-ordinated with the responsibilities of the Dominion Government departments working in related fields. Care has been taken to see that representatives of the Federal departments concerned sit with the Commisson's advisory committees at all stages of the planning. This course has been followed in order to ensure close co-ordination in order that public funds be used to the fullest advantage.

Research to be effective must be done close to the ultimate user of its results. On this account proximity of the research to the ultimate consumer gives better and quicker benefits. Although, in a confederation such as we have in Canada, a great deal of work must of necessity be done by the Dominion Government for all the people of Canada, nevertheless much of the research work must be done by groups which are close to local conditions. One of the best forms of training in the administration of any problem is a thorough experience in research in the field. An industry, government department, or university, with a strong research group working within the staff, is fitted much better to attack daily problems. The question of putting such a belief into dollars and cents, however, is not by any means an easy matter. The Provincial Departments, when requested for figures on research expenditures found it difficult to give an answer that stated the case clearly. It was only after considerable discussion that a consistent report could be prepared giving a summary of expenditures on research. It is hoped that, by further co-operation along these lines and by assistance from the Provincial Bureau of Statistics and Research, figures will be produced in such a way that economic principles may be applied and some measure of comparison may be set up to indicate the true value of research expenditures.

The Appendices submitted herewith and attached to the statement of financial requirements for the fiscal year 1947-48, summarize the preliminary findings of the Commission and its Advisory Committees. A final report will be submitted early in 1948.

†SUMMARY OF RECOMMENDED EXPENDITURES FOR RESEARCH—1947-1948

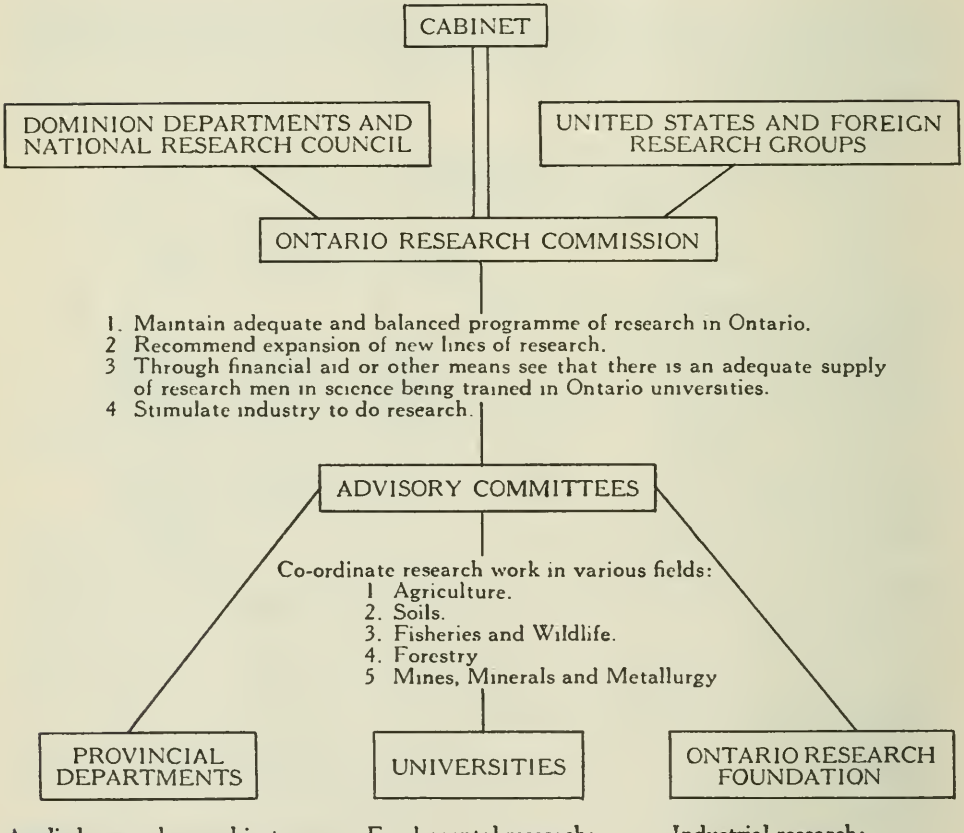
	Capital $	Operating $	Total $	
FISHERIES AND WILDLIFE COMMITTEE				
University of Toronto	1,000.00	12,575.00	13,575.00	
Royal Ontario Museum of Zoology	1,000.00	6,500.00	7,500.00	
McMaster University	6,100.00	10,480.00	16,580.00	
Queen's University	4,360.00	3,240.00	7,600.00	
University of Western Ontario	9,273.00	13,304.00	22,577.00	
Ontario Research Foundation	2,000.00	20,000.00	22,000.00	$ 89,832.00
FORESTRY COMMITTEE				
Queen's University	.....	1,590.00	1,590.00	
Ontario Research Foundation	2,000.00	18,000.00	20,000.00	
Unclassified as yet (sawmill practice)	.....	.....	25,000.00	46,590.00
AGRICULTURAL COMMITTEE				
Ontario Research Foundation	2,000.00	18,000.00	20,000.00	20,000.00
SOILS COMMITTEE				
Ontario Research Foundation	2,100.00	14,900.00	17,000.00	17,000.00
MINES, MINERALS AND METALLURGY COMMITTEE				
Ontario Research Foundation	12,000.00	32,000.00	44,000.00	
Unclassified as yet	.....	.....	56,000.00	100,000.00
INDUSTRIAL RESEARCH				
Ontario Research Foundation	.....	65,000.00	65,000.00	65,000.00
SCHOLARSHIPS (recommended by Ontario Research Commission)	.....	.....	.....	50,000.00
				$388,422.00

PROVINCIAL GOVERNMENT DEPARTMENTS RESEARCH EXPENDITURES—1946-1947

Department of Agriculture	$283,647.00
*Department of Education	77,000.00
*Department of Health	73,250.00
Department of Highways	50,000.00
Department of Lands and Forests	198,610.00
Department of Mines	131,000.00
Department of Planning and Development	3,000.00
*Department of Welfare	10,000.00
	$835,707.00
Ontario Hydro-Electric Power Commission	$109,600.00
TOTAL	$945,307.00

*These departments are not considered to come under the review of the Ontario Research Commission.

PROVINCE OF ONTARIO



Applied research on subjects of Departmental responsibility:
- Agriculture
- Lands and Forests
- Mines
- Planning and Development
- Tourist and Recreation
- Highways

Fundamental research:
- Western Ontario
- Queen's
- Toronto
- McMaster
- Ontario Agricultural College

Industrial research:

Fundamental research
Development

CONCLUSIONS

1. Research, to an extent greater than ever before, must be the foundation on which the economy of the Province is built.

2. Since the development and extension of research and, in consequence, of industrial progress in Ontario, is vitally dependent upon the availability of traind personnel, the Ontario Research Commission recognizes that the Department of Education, the Universities, the technical institutions, and the industry of the Province individually and collectively have significant roles to play in the training of persons who can give useful assistance in field.

3. The Commission wishes to emphasize the fact that senior members of the staffs of universities have very heavy teaching duties because of the unusally large registration of students. They are unable to give adequate time to the training of graduate students in research. With additional financial assistance suitable men could be added to the staff in order to meet this need This would be productive of very valuable results in increasing the number of scientists available for the urgent demands both in pure and in applied science. The Treasury Grants to the British Universities are being increased greatly in order that training in scientific research may be expedited.

4. The Commission is of the opinion that an important contribution to the carrying on of fundamental and applied research may be made by furthering the training of technicians in courses of the technical institute type extending over a period of one or two years at a level lying between that of the vocational high schools and that of the universities. The assistance of an adequate number of such persons would approximately double the effectiveness of the all too few fully qualified university graduate research workers.

5. The Commission desires to commend in general the longer and more advanced programmes of educational training in industry as productive of persons valuable to research. It is to be hoped that industry may be able to extend this service.

6. The facilities for research, in every field, require expansion, in equipment as well as in staff, and a larger measure of continuity to embrace long term problems is a necessary condition to future progress.

7. In most fields of research, despite the fact that there has been a multiplicity of research agencies, there has been a minimum of duplication of effort, due to the co-operation of the institutions concerned.

8. Provisions should be made so that discoveries resulting from research in our public institutions may be patented, with a view to ensuring that the financial gains arising from those discoveries are used to further research.

9. The successful "extension" policy of the various departments of agriculture warrants its introduction into other fields.

10. The Commission is of the opinion that industry in the Province has to be much more adequately informed on the value of research and on the results of research which may be helpful to individual industries. This is largely a question of "extension" and some form of co-operative effort in which the industries and government are jointly engaged. In the beginning govern-

ment may be asked to assume a considerable proportion of the expense. As industry takes over more and more of the responsibility of the programme the government share can be reduced. In Britain the government at present is carrying from 25% to 40% of the cost of the research which is being done by trade research associations.

11. Research on markets and on marketing must be, no longer, something of an afterthought. It is not a matter so much of scientific research as a question of the application of economic principles to production and marketing and should be a matter of study by an economic group.

12. In certain fields, for example agriculture, fisheries and wildlife and soils, the Governments must continue to assume major responsibility for research in the production field, and both Government and industry should begin work on the utilization of agricultural products and by-products.

13. In certain industrial fields, for example mining and minerals, Governments must continue to assume some responsibility, notably in the provision of research facilities beyond the means of private enterprise.

14. In many fields, existing organizations are competent to carry out a comprehensive Province-wide research programme, if provision is made for an expansion of facilities and personnel.

15. The activities of the Dominion Government in the field of research make it imperative that a close liaison be maintained at all times, if undesirable duplication is to be avoided and full use of available facilities is to be enjoyed.

16. Any marked extension of research activity in the Province will necessitate continuing, careful co-ordination of the efforts of all if fullest use of limited funds, limited personnel and limited facilities, is to be realized.

"There is probably more talk about research and its value in the post-war years than has ever occurred before. This is not confined to technical groups, but is featured in the public press, with the result that Government, industry and the public are becoming increasingly aware of what research can do—not only for the various organizations who expect to profit by such work—but what it may mean to people as a whole."*

The expansion of the research programme of the Dominion Government and the establishment of Provincial bodies, such as the Ontario Research Commission and the Nova Scotia Research Foundation, to investigate or direct research, reflects that public interest. That interest is a logical and commendable one, but it must be properly utilized and directed. Otherwise it can, unfortunately, lead to a great deal of loose, wishful and badly co-ordinated thinking.

The Ontario Research Commission recognizes the urgent need for research—research that is purposeful and that is co-ordinated. It believes that the objective of that research is the material objective of civilization itself—to prolong life, to improve health and comfort, to enhance happiness, and to enlarge productive ability and usefulness. The Commission recognizes, too, that research workers constitute the main reconnaissance staff in the attainment of that objective and feels that, because the research workers occupy that position, the problems of scientific personnel may best be discussed with the broader problem of research in general. Any co-ordinated long-term research programme implies the training and maintaining of competent staff; the justification for one is the justification for the other, and the success of the one will depend on the success of the other.

In the reports which follow the necessity for research in a particular field is discussed in the report on that phase of the Commission's investigations. For that reason no complete justification for a programme of research is attempted here. It will probably be sufficient to point that that the Advisory Committee on Reconstruction, after exhaustive studies, was convinced that research was fundamental to the success of any worthwhile programme of reconstruction. It recognized, too, that any research programme would of necessity have to be instituted after careful consideration of the problem of available personnel, and that provision for the training of an adequate number of research workers was a matter of extreme urgency.

The logic of this conclusion is unassailable. In any programme the quality and the quantity of available personnel are the main limiting factors. **Unlimited facilities and unlimited funds are of little avail without qualified and interested personnel.** The research worker may overcome some of the handicaps of limited facilities or limited funds by improvisation, but there can be no improvisation to compensate for lack of personnel, whether the lack is in the number or in the quality of the workers.

There is no doubt in the minds of the Commission that there is an alarming shortage of competent help available for research. This fact was emphasized by every one of the Advisory Committees and, in certain instances, despite a general lack of funds for research as a whole, the Commission was told that the funds in hand were sufficient to finance all the research work possible in the immediate future, because there simply was no possibility of securing personnel

*See R. K. Stratford — The Co-ordination of Research in Canada.

to conduct the work for which money was available. In this deficiency we are not alone, for a similar situation prevails in Great Britain and in the United States. In the case of the former a special committee was set up to attempt to compensate for lack of personnel by careful co-ordination of the efforts of those available. In the United States the Science Committee reported in part as follows:

"Shortage of experienced and competent research personnel has been acute in recent years . . . and in some fields first-class men are almost unobtainable."

This situation in the United States is of special significance to Canada and to Ontario. From the ranks of Canadian scientific personnel our neighbour is able to recruit men and women to ease the shortage which is handicapping it. It is true that we have some claim on these people—that of loyalty to Canada and appreciation of the fact that their training was and is carried out largely at the expense of their native land—but the attractions offered are, in most instances, such that it is difficult to refuse, particularly since our research has been so limited and the financial prospects rather meagre in comparison with those available in the United States. "Failure to recruit or retain," reported the Special Committee in Great Britain, "implies successful competition." That the competition of the United States for our personnel has been successful is readily recognized, but probably less appreciated is the fact that the "successful competition" by the Americans for personnel carries all the implications of successful competition in the struggle for markets—and we need those markets. Heretofore we have been satisfied to base our trade on the sale of our products in almost primitive form, but the demand for our basic products in that form is relatively inelastic, and this has been aggravated by the substantial decrease, due to the war, of the purchasing power of our customers. It must be realized that our chief hope of remedying what is otherwise a hopeless situation is to utilize more competently and completely our tremendous resources, directing our efforts to the frontiers of scientific research instead of to geographical frontiers as in the past. The solution is not in the production of more of the same products, but the production of consumer goods in less primitive form or in new form. To achieve that we must have research, and the prime requisite in that is, of course, adequate and competent research personnel.

Research in this country has suffered in the past both from lack of money and from a deficiency in the supply of trained research workers. The lack of money, no doubt, has been largely responsible for the inadequate supply of workers. Shortage of equipment, lack of trained assistants and of auxiliary services have together imposed an oppressive burden on the research worker, and in the case of many universities the burden of teaching has left potential high-calibre research workers little time for original investigations. There is an urgent need for better laboratories, and for more staff, not only that the teacher may have more time for research, but that he may have adequate facilities and time to instruct the students who to-morrow will man the staffs of research laboratories, university and industrial. For it is to the universities we must look, to a large extent at least, for ideas on the one hand and for men on the other.

Granted then, the urgency of the need for more adequate training facilities for the scientific personnel so badly needed, there remains the consideration of how to recruit and to retain sufficient competent research workers. The answer in both cases is the same—money; money for equipment which will enable

the research worker to carry on his work under reasonably adequate conditions; money to pay him what he is bound to be offered elsewhere; and money for the trainee in the form of fellowships, scholarships, bursaries. It is granted that very large sums are quite beyond our means, but a carefully planned programme could minimize the cost. However, it must be a complete programme. There is no advantage in providing partial training at public expense, or advanced training at further cost, only to have the personnel attracted elsewhere.

It is quite impossible to suggest a global figure required to meet satisfactorily the problem of adequate staff. Some of the Advisory Committees have endeavoured to suggest a minimum immediate programme designed to recruit interested, competent personnel, The most specific of these are outlined in the reports of the Advisory Committees but they should be considered as a mere beginning and not a complete plan. Further plans will have to be made to meet needs as they arise, and the Commission is certain that the careful objective consideration by a competent authority on suggested projects will not only prevent any waste of funds, but will produce results impossible of attainment under the present system, where research in one particular field is unlikely to be considered in the light of overall needs of the Province. It is quite obvious that a system of "priority research" would be of very great help to all, and that comparatively little additional expenditure would produce amazing results. The war has taught us what a tremendous power is represented by an organized, co-ordinated and trained team of research workers. The accumulated talents, experience and equipment of the scientists of Canada still form a gigantic reservoir whose potential energy could be quickly channelled in this direction or that, and brought to bear upon the problems, small or large, that seem most urgent at the moment. That is, they will form a reservoir as long as we ensure a constant stream of highly trained scientists to replenish the supply, and prevent, as far as possible, the draining off to competitors of those who might do for Canada what they will be asked to do for others.

It is the general judgment that Canada loses too great a proportion of her scientific personnel. During the period from January 1st, 1946 to September 30th, 1946, 574 Canadians, classed as technically trained, obtained exit permits to go to the United States.

The responsibility for retaining our trained personnel is not the direct responsibility of any one group but must be given active consideration by both government and industry.

SCHOLARSHIPS

The Commission realizes that the need for trained personnel cannot be met completely by the provision of scholarships. Neverthless, to assist students with ability and as an adjunct to a complete programme the provision of financial assistance to outstanding students plays a useful part.

During 1946-47 the Ontario Research Commission requested that $20,000 be made available to provide scholarships for research students. Through recommendations from the Advisory Committees ten scholarships were granted for work to be done during the 1946-47 term. These are listed below:—

Name	University	Recommended by	Amount	Project	Supervisor
			$		
Ferguson, A. E.	O.A.C.	J. F. Francis	1,000	Poultry Diseases	Francis
Gartley, K. M.	O.A.C.	J. F. Francis	1,000	Biochemistry	Patterson
Graham, A. R.	Queen's	R. C. Wallace J. E. Hawley	600	Mineralogy	Berry
Curtis, E. C.	Queen's	R. C. Wallace	500	Plant Ecology	Aikman (Iowa State)
Denyes, H. A.	Queen's	R. C. Wallace	1,000	Animal Ecology	Dice (Ann Arbor)
Wragg, L. E.	McMaster	A. E. Warren	1,000	Wildlife	Judd
Sanderson, Mrs. G. (nee Lustig)	O.R.F.	H. B. Speakman	2,400	Climate	Chapman
Baldwin, N. S.	U. of T.	E. M. Walker	500	Ichthyology	Fry
Martin, N. V.	U. of T.	E. M. Walker	1,000	Trout	Fry
Irvine, K. E.	U. of T.	R. R. McLaughlin	500	Waste Sulphite liquor	McLaughlin
Clemens, H. P.	U. of W.O.	W. S. Fox	500	Fresh-water cod	Battle
			$10,000		

A copy of the proposed regulations governing scholarships follows.

Regulations Regarding Scholarships

1. These scholarships are intended, not to facilitate attendance on ordinary collegiate studies, but to enable students, who have given distinct evidence of capacity for original research or students who have at least won high distinction in scientific study during their undergraduate course, to continue the prosecution of science with the view of aiding its advance or its application to the industries of the country. Evidence of this capacity is strictly required, this being the main qualification. The most suitable evidence is the submission of a satisfactory record of research already performed.

2. They are open on equal terms to men and women, and are awarded to the applicants who are deemed best qualified by the evidence submitted.

3. An applicant for scholarship must be a British subject resident in Canada.

4. An applicant to be eligible for a first award must not have passed the thirtieth anniversary of his birth on March 31st of the year of application, except in the case of war veterans.

5. A candidate must (1) be a bona fide graduate of a university or college in which special attention is given to scientific study, or (2) have received an equivalent training in an institution possessing adequate facilities of a scientific character for providing such training.

6. The departments of science in which capacity for research will be accepted as qualifying for an award are: Agricultural Sciences, Biology, Bio-Chemistry, Chemistry, Engineering, Forestry, Geography, Geology, Mathematics, Metallurgy, Mineralogy, Physics, or other approved departments.

7. Application for a scholarship must be made by the candidate to the Ontario Research Commission. He shall submit a complete record of his academic career and standing on entrance. Recommencations must be submitted from the heads of the scientific departments with which he was connected, and professors or instructors under whom he studied, showing that in their estimation he promises to be worthy of training for scientific research. All such recommendations must be forwarded to the Ontario Research Com-

mission by the professor recommending the candidate and through the head of the department concerned. The candidate shall state the institution at which he intends to study, and the general line of work to be followed. The application will be considered and decided upon by the Ontario Research Commission or by a special committee appointed by the Commission.

8. Each applicant must arrange for his admission to some approved institution and submit with his application a statement from the supervisor under whom he intends to work in such institution that such supervisor has agreed to undertake the supervision of his work with the approval of the head of the department concerned. Such supervisor will be expected to submit to the Ontario Research Commission a confidential report on the grantee's work at the mid-year and on the conclusion of the award.
9. The date of the beginning of tenure of an award shall coincide with the beginning of the academic session of the institution at which the grantee is to carry on his work. In very exceptional circumstances the Commission upon receipt of a formal application from a grantee, may permit a change of tenure to be made.
10. Successful candidates are required to devote themselves for a period of at least eight months of each year wholly to the objects of the award, and during that time may hold a position of emolument or engage in teaching only with the approval of the Commission on such terms as the Commission may decide.
11. The holder of a scholarship shall furnish on or before February 1st a detailed mid-year report of his work up to that time; and also on completion of the tenure of his award, and not later than July 31st, a complete and detailed report of the work carried on during the entire year.
12. The Ontario Research Commission shall have the right to publish under its own auspices information arising from work done under an award, and no paper covering work carried out under an award may be published without permission from the Commission.
    In each case a copy of the manuscript shall be filed with the Commission before publication, and evidence shall be submitted that the supervisor who directed the work has approved the manuscript and the plans for publication; information shall also be furnished as to the manner in which it is proposed to publish and the expected date of publication. One reprint of the published paper shall be forwarded to the Commission as soon as available. In published papers, due credit shall be given to the Ontario Research Commission for the assistance received therefrom.
13. The scholarships will have a value of $500, $900 or $1200 depending on the experience and qualifications of the applicant.*
14. Awards are payable as follows: 40 per cent on beginning work; 50 per cent on receipt of a satisfactory first half-yearly report; 10 per cent after the expiration of the period of tenure and the submission to the Ontario Research Commission of a satisfactory report on the work of the holder for the whole period.
15. Grantees who have to travel 300 miles or more may be granted, at the discretion of the Commission, an allowance toward travelling expenses. Such travel grants shall be based on the distance between the point where the award is tenable and the point where a grantee was located during the preceding year.
16. Application for a scholarship must be made not later than February 1st.

*During the past year scholarships were not confined to these specific amounts since the regulations had not been finally decided upon.

Present Conditions in Industry

In Ontario, as in all Canada, the most striking result of the war is to be found in the rapid expansion of industrial productive capacity.* And, even though some of the production units included in the amazing growth under the stimulus of war may be of no use to industry in times of peace, nevertheless the remaining increase of production facilities will have a profound effect not only upon the distribution of goods in the province, but in all Canada, and upon the international trade of the Dominion. Properly directed, these increased facilities may contribute enormously to the public welfare. But it must be recognized that while industry, geared to war-production, may be temporarily sustained in the postwar period by the backlog of demand for goods in restricted supply during the war, and by the requirements for the rehabilitation of those regions devastated by war, it is imperative that this "sellers" market be recognized as an abnormal one, and that, if a period of recession is to be avoided, adequate planning must be undertaken at once. This planning must be based on research, with a view to the production of new articles to meet new demands, or to the reduction of manufacturing costs with the object of extending the market for existing goods. To limit our "Planning" to such efforts as the restriction of output, whether by limiting the scale of effort or by shortening the hours of labor, with a view to spreading over a longer period the production necessary to meet existing demand, will merely add to the ever-present danger of inflation. Goods must flow as rapidly as possible from the production line, and, while the peak demand is being met, plans must be made for the adjustment from a period of abnormal markets to the more stable conditions of normal times.

Reasons for Lack of Research in Industry

It seems quite likely that a considerable portion of Canadian industry lacks any appreciation of what research might mean to it. This is not remarkable. The superficial enthusiasm for research immediately after the World War I, based on inadequate understanding, led to its use chiefly as "advertising copy", with the result that many industries obtained a completely misleading concept of the value of research. Moreover, since many of our industries are subsidiaries of companies in the United States, they have been content to leave to the parent company the solution of technological difficulties and the discovery of new marketable products. Further, although it was demonstrated during the war that Canadian industry could produce articles exactly to customer specifications, that customer was in a position to make known exact needs, and, in many cases, to provide designs. Such a situation left to industry responsibility for investigation of manufacturing processes only, and failed to emphasize the fact that there was much fundamental research behind the design. In peacetime the articles to be produced must be determined and designed through fundamental and applied research by the industry itself. To accomplish this will require considerable time and considerable investment, but industry, if it is to be successful, cannot afford to await developments. It must bring them about.

To most of our smaller industries—industries which make up more than ninety per cent of the number of industrial establishments in Ontario and which give employment to some fifty per cent of our factory workers—this idea is

	1937	1943
*Establishments	9,796	10,587
Employees	321,743	570,017
Gross Value of Products	$1,880,388,188	$4,221,101,063

completely foreign. In these enterprises there is a minimum of trained personnel, scientific or otherwise, who normally provide the stimulus for investigation and development. Too often, probably because of their origin, these companies scoff at the so-called "scientific approach," and rely completely on empirical methods, with the result that many of them employ obsolete techniques. These may mean not only higher costs but a product of inferior quality and there can be but one ultimate outcome of such a situaton—the failure of the business.

An extension at the provincial level of the present Technical Information Service of the Department of Reconstruction, perhaps through the Ontario Research Foundation, would be a step in the right direction.

Government Interest in Research

Nor can the Government in times of peace be expected to assume complete responsibility for industrial research. It is true that the social and economic implications are of such magnitude that the Government has a vital interest in industrial welfare and should make every effort to guard against industrial collapse. But its efforts should be those of an assistant—an assistant urging and helping industry to widen its horizons, that there may be suitable outlets for the tremendously increased capacities for production. Unless these outlets are found the results may be catastrophic. Though this should be mainly the responsibility of the individual industries a certain amount of government assistance generally applied would help to co-ordinate the efforts of industry.

General Factors to be Remembered

In plans for any programme of industrial research two limitations must be borne in mind—the limitation of time and the limitation of funds. Our most likely industrial competitors, United States and Great Britain, are intensively active in research matters, while Russia, a potential competitor, is expending probably more in money and in effort than either of the others. These countries are recognizing, too, that there must be intimate co-ordination of effort and mutual stimulus by industry and agencies for fundamental research. It might well be that the effort being put forth in these countries will, if we delay, cause us to be hopelessly outdistanced in the staking of claims on the new industrial frontier.

Although we are, as yet, at no disadvantage in the matter of time, the same fortunate situation does not prevail in the matter of funds. We never can hope to match, in total expenditure and probably in per capita expenditure, the amounts which will be available for research in the United States, Great Britain and Russia. But the measure of total or per capita expenditure is not necessarily the measure of success. Quality of research can compensate for the disadvantages of less extensive investigations. There is every reason to believe that our scientific personnel is as competent as any group in the world, and that our industries are as adaptable as those of other countries. The prime necessity, it is apparent, is the judicious use of the talents and the facilities that are ours. The harnessing of those talents and facilities, through a co-ordinated research programme, was eminently successful during the war. They can be used just as effectively, surely, for purposes of peace.

Difficulties

The problem of proper co-ordination and extension of industrial research is not an easy one. The general apathy referred to previously is reflected in the

inadequate research machinery at present in existence. It is true that many of the larger industries do operate research laboratories, and, in certain fields, there are commendable facilities. But, by and large, probably industry is concerned less with widening its scope and its abilities than it is with filling orders, trusting to a competent sales staff, to newspaper and radio advertising, and to courtesy and service for the maintenance of markets for its products.

There are, in Canada, no laboratories comparable to those of the DuPont, General Electric and the Standard Oil Development Company, and it seems unlikely that there ever will be, for reasons which are obvious. We have no extensive semi-public applied-science research laboratories, such as the Massachusetts Institute of Technology, the California Institute of Technology, the Carnegie Foundation, nor Research Stations such as those for aeronautical research at Langley Field and Moffett Field. Nor are our aircraft industries able to support research laboratories on the scale found necessary by the aeronautical industries in the United States. It would seem that, since our industrial operations are on a scale which makes private research in certain fields impossible, the responsibility for these large scale investigations must, of necessity, be assumed by the Government.*

It should be remembered, too, that a considerable proportion of our industrial productive capacity is in units so small that the maintenance of their own research laboratories is quite impossible. While the larger industries will probably, to a greater and greater extent, make provision for some research, the problem of the small industry will remain. The need for government help in the field of agriculture has long been recognized, and there would seem to be every reason why similar services should be extended to small industry. Great Britain recognized this during World War I, and gave financial help and encouragement to Research Associations, the aim of which was to provide co-operative research facilities to the various competing companies in a particular field. Twenty-eight of these associations have been formed, or are in the process of being formed, and while the financial support they have received from members leaves much to be desired, and while they have been no panacea for production and marketing problems, they have rendered considerable service.

Some of the industrial groups in Ontario and in Canada are discussing just now the possibility of co-operative action. Though many are loath to work together at the research level for competitive reasons, and because they fear the domination of government bureaus, there are some who will work co-operatively and with a government sponsored group as well. An example is to be found in the textile industry, and in this industry, at least one medium of approach would be through the Textile Division of the Ontario Research Foundation.

Another difficulty is that of the personnel. Lately there has been a pronounced tendency on the part of those companies aware of the possibilities of research to entice scientific personnel from the universities. While this may answer an immediate industrial need, it may well have unfavourable repercussions over a period of time. The universities still are the major training ground for scientific workers, and if the instructors are enticed from the university laboratories, the quantity and quality of instruction given may suffer considerably. The inducements offered by private interests are many, and this coupled with those from other countries, may easily promote a critical shortage of teachers within our universities. Industry must appreciate this fact, if it is to be provided

*See C. J. Mackenzie—Research in Canada—Page 38.

with a steady supply of competent scientists. It should be possible to evaluate the need for instructors and for industrial research personnel in the light of long-term requirements of industry itself.

Still another difficulty is that arising out of the question of patents. Those engaged in fundamental research are averse to restricting discussion of the problem at hand to a few persons, and research leading to post-graduate degrees may require publication of results. For that reason private companies have hesitated to finance research in universities. More recently that attitude has been modified, and, when required, arrangements have been made to meet special conditions. Discoveries within the university, arising out of research financed by public funds, present further patent difficulties, as the university may not wish to patent the idea and private interests may do so. The weakness here seems to be the lack of an organization such as the Research Corporation in the United States. This organization, described as "an engineering foundation organized to transact business for the advancement of science, to which profits are applied," takes over and patents discoveries made in the laboratories of universities and technical institutes. The profits from the sale of patent rights are applied to grants in aid of research to be carried out in such institutions. The scheme has been quite successful, and there are now several such foundations in operation.

Recommendations

Recognizing the urgency of the situation, and in spite of the limitations in the matter of funds, the paucity of machinery for research, the apathetic attitude of a considerable portion of industry, and the fact that information on the subject is quite inadequate, the Commission feels that a start on a co-ordinated programme of industrial research can and must be made, and respectfully submits for consideration the following recommendations:—

1. The immediate institution of a campaign designed—

   (a) to stimulate the interest of industrial management in research,

   (b) to encourage the use of the library service of the National Research Council,

   (c) to extend the use of the facilities of the Technical Information Service, of the Research and Development Branch, Department of Reconstruction and Supply, by direct action in Ontario through the Ontario Research Foundation,

   (d) to arrange for more direct extension of research results to industry on a basis of free assistance for a trial period developing through a part pay period to a point where the research effort in industry would be mainly supported by the industry.

2. The encouragement of industry to take advantage of existing taxation benefits for research and the investigation of the possibility of obtaining further concessions in the matter of taxation of industries, with a view to encouraging expenditures for research.

3. Investigation of the advisability and practicability of the formation of Industrial Research Associations for co-operative research, and of granting some financial assistance to such associations, if any are formed, with the definite

understanding that these organizations are to be managed and maintained by the interested industry.

4. Endorsation of the suggested extension of the National Research Council Laboratories, the Ontario Research Foundation, and other such laboratories, to include facilities for research, both fundamental and applied, beyond the financial means of Canadian industrial institutions.*

5. The establishment of a patent-holding organization similar to the Research Foundation in the United States, to patent discoveries made by universities, research associations, etc., with the profits to be applied to further research and extension work in and by such institutions.**

6. The formation of an Advisory Committee, or Committees, representating Industry (preferably through some such agencies as co-operative Research Associations) to make known to the Ontario Research Commission the needs of industry.

7. That the Ontario Research Foundation be provided with such funds that are necessary to secure the additional space and personnel to—

(a) Give the necessary leadership in organization to promote the foregoing six recommendations.

(b) To secure qualified personnel to diagnose the problems of individual manufacturers and to direct them to the best places for aid in each particular case.

(c) To make possible fundamental research for trade groups; such research to be paid for in the main by such groups but supplemented by the government on an agreed percentage basis.

(d) To assist individual manufacturers to promote research either within the Foundation or within their own facilities, or to assist individual manufacturers by giving guidance in the setting up of facilities for testing, control, and minor investigational work—with or without government financial aid.

(e) To act in conjunction with Industrial Canada in the promotion of a continuous and persistant stream of research ideas to the Ontario members of the Canadian Manufacturers' Association to the end that all members will eventually become research-conscious, and interested in a review of their own manufacturing position.

(f) To encourage and to assist where possible (or to advise where assistance can be secured), individual manufacturers to bring about simplification and improvement in the efficiency of methods of production and the streamlining of their manufacturing operations.

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*See further—C. J. Mackenzie—"Government Sponsored Research" in Research in Canada, page 37.

**See further—Problems of Scientific and Industrial Research, A Statement—Nuffield College, page 60.

MEMORANDUM ON INDUSTRIAL RESEARCH SUBMITTED BY CANADIAN MANUFACTURERS' ASSOCIATION

December 6th, 1946.

The Chairman and Members,
Ontario Research Commission,
47 Queen's Park,
Toronto, Ontario.

Gentlemen:—

The Ontario Division of the Canadian Manufacturers' Association, which embraces within its membership some 2,700 manufacturers, welcomed the appointment of the Ontario Research Commission by Order-in-Council in August 1945. It noted further that the qualifications of the Commissioners appointed thereunder insured a thorough and comprehensive investigation into the matters specified in the terms of reference of the Commission. The Association has learned that the Commission will shortly be making recommendations concerning its work and desires to submit some observations on the application of technical and industrial research, with particular reference to the Ontario Research Foundation and industry in the Province of Ontario.

The Canadian Manufacturers' Association has always fully recognized the value and necessity of research for the development of industry and has made a valuable contribution towards its encouragement. Its interest was particularly marked during the first world war. It may be of interest to the Commission to record that in February, 1923, the Association arranged a conference at Ottawa to survey the work which had been done on research and to receive suggestions in regard to what might be done in the future. This conference was attended by representatives of the Dominion Government, of leading universities throughout Canada, of agriculture, and of private research organizations, as well as by members of the Association. The valuable information collected at this conference was later published and distributed by the Association.

In order to continue the work done by the Association in regard to industrial and scientific research, the Executive Committee appointed a special Committee in September, 1923.

This action by the Association, and similar action by other interested bodies, revived interest in research at a time when it had declined greatly, and, finally, the Research Council Act was passed in 1924 under which the Dominion Government Honorary Advisory Council for Scientific and Industrial Research was constituted a separate body with corporate powers under the name of the National Research Council. Under the Act, the Council was empowered to make researches with the object of improving the technical processes used in the industries of Canada, and to discover processes and methods which would promote the extension of existing, and the development of new, industries.

In line with its educational programme, the Association held conferences on industrial and scientific research at its Annual General Meetings in 1945 and 1946. These attracted a great deal of interest and many excellent contributions were made to the subject by leaders in this field and in the discussions which took place. It may be of interest to note that while at the 1945 conference some of the speakers were from United States companies, all those taking part in the programme at the 1946 conference were representatives from Canadian Government departments, Canadian universities, Canadian research institutions and

Canadian manufacturing companies. The proceedings at these conferences were fully recorded and widely distributed throughout Canada, the United Kingdom, the United States and other Empire and foreign countries.

In the summer of 1945 it was decided to inventory research facilities in Canadian plants, and to this end information was sought by the Association from its membership across Canada. The results were highly informative and interesting. Of the 577 manufacturing firms replying to the questionnaire, 402 reported that they maintained laboratories for the creation of new products and techniques, improvement of existing products, product and quality control and testing, and that over 3000 persons were engaged in work in connection with them. Many firms also indicated that they used the facilities of government institutions or private laboratories. It is also a matter of interest to record manufacturers spent almost two and a half times as much money on research in 1944 as they did in 1938.

The Association also took a leading part in the establishment of the Ontario Research Foundation, and as the Commission is aware, industry shared with the government of the Province in the endowment upon which the capital structure of the Foundation rests. In the eighteen years that the Foundation has been in operation, it has made valuable and extensive contributions to the scientific knowledge not only of the Province but of Canada. Its annual reports reflect the measure of its work and the high quality of the goods produced in this Province can be attributed in considerable measure to the careful research work which has gone on within its walls.

The governing body of the Foundation in its formative stages laid down a programme which was designed to cover a very wide field of research for the benefit not only of industry but in the broader fields of agriculture, pathology and biochemistry. This programme was under way when the business recession of the 30's overtook the country. The Foundation, like every other institution, felt the effects of this. Retrenchment and financial conservation was the order of the day. Some of the long-term projects which, in many cases involved substantial expenditures, were curtailed or abandoned. Other projects which had been completed were not renewed and this retraction extended even to the short-term investigations which were being carried out for a large number of industries.

These policies, however, were not adopted by all. Many industries continued to take a long-range view on research, foreseeing that its value in respect of the improved quality and lowered costs of their products would be justified when the expected recovery took place. It is hardly necessary to state that these industries reaped the reward of their perseverance. It is also gratifying to record that practically all those industries which had undertaken to share in the endowment, continued their payments into the fund during these years.

It is a matter of record that, during this period the Foundation did not restrict its usefulness. On the contrary, it pursued with closer attention the technological problems which arose as the result of this period of industrial stocktaking and broadened the scope of its fundamental research into those fields not directly allied to industrial research but which were specifically designated in the original programme as requiring investigation.

Following this period of recession and in the period before and during the war, industry underwent significant changes. During this time considerable expansion occurred in the industrial field, notably in the establishment of numbers of smaller industries. It was also significant that this period saw a newer generation of management taking over the direction of many industries. It is, therefore, perhaps not surprising that, preoccupied as it was with its immediate problems, this body of industry under this newer management does not have the close relationship with the Foundation which the industries with which it was associated in its early years, enjoyed.

There has been some divergence in the paths followed by the Foundation and this body of industry to which we have referred. No criticism of the Foundation is intended in referring to this situation. The Foundation is an established institution, equipped and prepared to assist industry and to carry on work in many fields and it has not counted amongst its functions the work of bringing itself continually to the attention of those who might profit from the utilization of its services.

Nevertheless, this gap between the Foundation and a considerable body of manufacturers, particularly the smaller manufacturers, exists today, and the Ontario Division respectfully submits that the Commission include in its investigations ways and means by which this gap may be closed and the Foundation and the industries which it was designated to serve, restored in greater measure to their original relationship.

The Ontario Division of the Association views this situation with some concern and it was with the object of considering what steps might be taken towards assisting to correct this that, during the summer, it appointed a special Committee to investigate the matter and to bring forward proposals which it is hoped would, if acceptable to the Foundation and to industry, result in a resumption of the original programme intended.

Discussions and conferences have been held with Officers of the Foundation in the past few weeks and it would appear, at this stage, that initial steps towards the development of a programme designed to bring the Foundation and industry in closer alignment, might be considered through three lines of approach. These are:

(a) A programme conducted by the Foundation and designed to bring the work and facilities of the Foundation to the attention of manufacturers in the Province, and in particular to the smaller manufacturers.

(b) Further exploration by the Foundation of the possibilities of bringing groups of industries having common problems into a closer relationship with the Foundation for the purpose of solving these problems on a basis of mutual benefit.

(c) The encouragement of organizations of scientific and productive personnel within broad groups of industries, particularly those maintaining research facilities of their own, for the interchange of ideas and information which would help them in their work.

In the foregoing the Ontario Division of the Association would be prepared to co-operate as far as possible.

If the suggestions given above were completely developed expansion of the Foundation would be necessary, and as these suggestions are considered as part of an even greater programme of endeavour in the realm of industrial and scientific research, the Association considers, therefore, that it would be necessary for the Foundation to adjust its facilities to take care of the expansion which would result from such a programme.

In the past the Foundation has at all times been allowed to conduct its scientific work as an independent organization beyond the sphere of governmental jurisdiction. By reason of the peculiar nature of scientific work, this has undoubtedly been a fortunate policy in which the Association strongly concurs. It is urged that no measure be considered that would interfere with this independence, as such circumstances are all-important to the performance of a high standard of scientific work. However, the Association believes that the government can, without departing from this principle, perform a useful function by providing material assistance as required to the Foundation to be devoted primarily towards investigations and research into problems, the solution of which will benefit industry as a whole and in addition will enable the Foundation to develop a continuing programme of publicity designed to inform industry of the potentialities of industrial research and the facilities which exist in the Foundation for this purpose.

The Ontario Division of the Association would, in conclusion, remind the Commission that the Board of Governors of the Foundation includes representatives of a number of branches of Ontario industry, as well as of science, and urges that whatever measures the Board intends to advance towards broadening the services of the Foundation, be favourably considered by the Commission as a contribution not only to the industrial community but to agriculture, the forests and mines, and educational institutions of the Province, and thus to the ultimate benefit of all its citizens.

Thos. E. Boyce, Chairman,

Ontario Division,

Canadian Manufacturers' Association.

THE ONTARIO RESEARCH FOUNDATION

The following is a brief presented to the Ontario Research Commission on September 18th, 1946, by the Executive Committee of the Board of the Ontario Research Foundation.

Statement by Mr. E. G. Baker, Vice-Chairman

The Board of the Foundation which I represent is grateful for the opportunity given to us of speaking to this Commission about our work. We feel that the great majority of industrialists have an increasing realization of the contribution which applied science has made and must make to the solution of the many problems which confront them today. What is generally accepted in the atmosphere of the large industrial unit is equally applicable in the case of the many thousands of smaller plants scattered all over this Province. Similar methods must be employed more and more if we are to use wisely the basic raw materials and agricultural products of Ontario. The problem is how to make available to Industry and the Government the facilities for research which they require. We have endeavoured to face up to these problems in the past and have made a distinct contribution to industrial development which is far in excess of the expenditure involved. The opportunity before us now is much greater, and we welcome the privilege of outlining to the Commission our plans and our immedate requirments. May I assure you that up to the very limit of our own available resources we shall press forward and try to equip the Foundation with good men and the necessary equipment. At the present time we are enlarging our laboratory building. Steps are being taken to secure additional leaders in special fields of research. It is with strong conviction that we ask this Commission to recommend certain items to the Government. The need and the opportunity are before us, and it is on the basis of our past record and the increasing demand for our services that we respectfully ask for your support. I would ask Dr. Speakman, Director of the Foundation, to address you and present n greater detail the views which I have endeavoured to express.

Statement by Dr. H. B. Speakman, Director

The Ontario Research Foundation was established by provincial statute in the year 1928. It was the outcome of a movement which started among both industrialists and scientists during the first world war. The problems of manufacturing, shortages of essential materials and the lack of trained personnel left in their minds the thought, "Why should Canada be so dependent on other countries for applied research facilities?" I would couple with this the feelings and thoughts of men, who like myself were engaged in university work, as we watched and assisted the steady stream of good men, trained for research, crossing the boundary to find work and to contribute immeasurably to the economic and intellectual life of our neighbour. As a result strong representations were made from time to time to the Government by the organizations of manufacturers, by the Royal Canadian Institute and other scientific bodies that steps should be taken to establish suitable laboratories in this province.

In 1927, the Premier of the Province, the late Hon. C. Howard Ferguson, took the necessary steps to bring this about, and in the following year introduced the Bill which I have mentioned. The objects of the Foundation were defined in broad terms and the Government asked for authorization to contribute a sum of one million dollars to the Foundation, provided a similar sum was raised

from institutions and private sources. Later the Bill was amended to allow this sum to be exceeded owing to the fact that approximately $1,600,000 was promised, and in the subsequent 5-year period over 90 per cent of this amount paid by the original subscribers. The Bill was passed with the unanimous consent of the Legislature.

The Government in addition placed at our disposal a house on the crescent of Queen's Park and subsequently made the adjacent house available. In 1929 steps were taken to erect the lower portion of a fire-proof and properly designed laboratory building to which the Foundation is now adding two floors. The present Government has vested in the Foundation the title of both the land and buildings.

In 1944, the present Government of the Province introduced a new Bill which changed slightly the administrative detail, and it is now possible to describe the Foundation as a Board appointed by the Lieutenant-Governor in Council to administer a trust created by the Government and private subscribers for the furtherance of applied scientific research in this Province.

The objects of the Foundation as defined in this Bill are as follows:

(a) The conservation, development and utilization of the natural resources of the Province;

(b) the development and utilization of the by-products of any processes involving the treating or using of the mineral, timber or other resources of the Province;

(c) the development and improvement of methods in the agricultural industry and the betterment, welfare and progress of farm life;

(d) the mitigation and abolition of disease in animal or vegetable life and the control and destruction of insect or parasitic pests; and

(e) the improvement and development of industrial materials, products and techniques.

It will be clear to members of the Commission that no institution starting from scratch and with comparatively meagre resources could be expected to cover such a large field of both science and technology. May I state in brief form one or two of the principles of policy which guided the Foundation in the early days:

(1) We asked ourselves what work was being done already and endeavoured to establish and maintain contact with other institutions, notably the National Research Council and Departments of Government, in order to avoid unnecessary duplication of effort. You will observe that I say, unnecessary, because I sometimes wonder whether it is sufficiently realized that confirmation of scientific work and even a certain amount of healthy competition are good for all concerned. For reasons which I need not enlarge upon we left alone the electrical field, medical problems, the petroleum industry and the production problems of agriculture. We endeavoured to supply the needs of basic industries such as metallurgical, food and textiles.

(2) The basis of our organization was and is a small group of senior and competent men with research ability and a technical knowledge of some special field. May I say with confidence and in the light of their accomplishments that in Dr. Ellis, Dr. Westman, Dr. Goodings and Dr. Marshall we have a team which

conforms with this fundamental requirement. They all left good positions, many of them in the United States, to return to Canada and to engage in work which they enjoy and which appeals to their sense of loyalty and obligation. In speaking of them I am referring to the very core and essence of this or any other research organization. All other considerations are of seconadry importance.

(3) The objectives outlined in the Bill clearly indicate the dual function of the Foundation. In the first place it is assumed that we are to be responsible for the investigation of certain basic problems of interest to the people of the Province as a whole. Secondly, we are to co-operate with and assist industrialists in the solution of their special problems. In the one case our client is the Government and in the second a group or a single manufacturer. It was the intention and it has been the consistent policy of the Foundation to ask both clients to pay for the work done.

This policy, and speaking now with particular reference to the Province as a whole, was accepted and continued in operation for approximately 6 years. During this period we carried out investigations relating to contagious abortion in cattle, the lignite deposit in Northern Ontario and the low-grade iron ores of the Province. In every case a splendid contribution was made to the scientific and economic aspects of these basic problems. The lignite report is as authoritative now as the day it was written, and it illustrates the great value sometimes to both Governments and private individuals of a negative report. In the field of contagious abortion my colleagues not only made a contribution to the scientific side, but what was of even greater importance, they demonstrated for the first time that a typical area of Southern Ontario could be freed from this menace to the dairy farmers of the world by working in co-operation with a group of average "dirt" farmers. They did most of the work and carried cheerfully the initial losses which were associated with the elimination of reactors from their herds.

Later in this statement I shall have more to say about the iron ore investigation.

Each of these major problems was undertaken at the request of the Government and in all cases we worked with the fullest co-operation of officers of the Departments concerned. For reasons which I need not discuss the policy of the Government changed in 1934 and their financial support of approximately $30,000 per annum ceased. We continued, however, to render a service of this character by maintaining a small unit in pathology and parasitology and in physiography. May I ask your permission to return to these later.

During the early years the industrial research field, supported by industry, was profoundly influenced by events occurring in the autumn of 1929. Confidence and enthusiam for research gave place to acute anxiety and for several years the world-wide depression exerted its influence. Not only individual companies but groups of manufacturers changed their plans and terminated projects which had started in our laboratories. Looking back now it is possible to state that this experience was for us not free from blessings. The institution did not expand in the way which had been contemplated, but we were able to grow I believe on sound lines and in the light of experience, not excluding the results of mistakes. In addition, and of far greater importance, the men we had secured were enabled to concentrate for several years on internal research and to open up fields which have produced a harvest in these later years. May

I call your attention to the list of published papers attached to the annual reports of the Foundation. To-day that work is the basis for much of our contribution to industry in our Fellowship laboratories.

May I say a few words about the war period. Our contribution commenced before the declaration of war in September 1939. We had been at work, quietly and without publicity, developing in co-operation with a group of manufacturers first of all the basic steels required and later a weapon which played an important part in the war. In the early months of the war the Inspector General visited us and found a nucleus of trained and keen men who were glad to co-operate and create with commendable speed the necessary facilities for testing gauges and other essential war supplies. In addition there is the story of assistance rendered to private corporations confronted with new products and processes and demanding standards of the highest efficiency. May I say with confidence that the period 1939-1946 is sufficient and ample justification for the steps taken in 1928. The Foundation proved its worth when called upon.

So much for the past, what about the present and future? With the return of peace we find ourselves under great pressure. There is a demand for research which is taxing to the limit our available space and taxing beyond the limit the resources of a small group of senior men. Our service to industry is of two types, the long and short term investigation, and only in exceptional cases are we concerned with routine analyses or tests. At the present time we have 18 major projects sponsored by Companies. A Research Fellowship involving one or more competent graduates with technical assistants is established and the unit as a whole placed under the supervision of one or a group of my senior colleagues. With each Fellowship there is associated an advisory committee which includes representatives of the organization sponsoring the investigation. In one case the company is spending alone an amount equal to our external revenue for research in the early years. More Fellowships are in prospect as space and suitable men become available. I feel that it is unnecessary for me to stress the importance of this work. Personally I attach equal importance to the short-term work. It is the one way in which we can render positive assistance to the smaller manufacturer, and several hundred are making use of the opportunity. The problems cover a wide field of both science and technology and the work can only be done under the guidance of trained and experienced men. The returns to the firms are in many cases out of all proportion to the sums of money involved. You may ask, "Why is this short-term work not done within the industrial units concerned?" My answer is clear and I believe it to be sound. A small industrial unit can and should equip itself to take care of routine testing and control work. It cannot equip a research laboratory with either the specialized equipment or personnel required. Progress will come if such units can be persuaded to employ a suitable trained person whose main functions will be to formulate the problems as they arise and establish and maintain contact with laboratories, both public and private, where the required information or research service can be secured. May I interject an observation at this point. There is a tendency to emphasize the competitive aspects of business and secrecy and to overlook the amount of co-operative effort including a readiness to pool knowledge and experience gained in privately-owned laboratories. The gap in the desired chain of events is more often than not the man to secure and apply knowledge which is available.

These two types of service to industry will be maintained and developed to the limit of our available resources. We hope to strengthen particularly our

senior staff and to put new life into internal, fundamental research. As a proof of this determination my Board has authorized the extension of our main building. We are, however, confronted with a picture with three aspects: (a) the demand the opportunity are greater, (b) costs are rising and have almost doubled since 1938, (c) our own revenue is gradually falling due to the change in interest rates. To meet the need we have approximately one-half of the fundamental research power we possessed in 1938. Do I need to enlarge on the need for having more than one senior man to supervise and inspire research in the whole field of textiles? This is one example.

In order to assist the Foundation to discharge its responsibilities and its dual function which I have discussed briefly, the executive has authorized me to present to the Ontario Research Commission for your consideration and approval the following recommendations:

(a) The Government to be responsible for the amount required to carry on two major fields of research which we have initiated and supported for over fifteen years in the general interest of the Province, namely parasitology and physiography.

(b) The Government to authorize and support additional research projects which are basic to our provincial economy and associated with the development of Ontario's natural resources.

Parasitology

Our activities in Parasitology are all that remain from the extensive biological programme which the Government supported during the early years of the Foundation, This work is altogether in the public interest and is not a revenue-producing enterprise.

In recent years the work has been concentrated on the blood parasites of Ruffed Grouse with a view to a better understanding of the cyclical fluctuations which occur in the population of this important game bird. Of five blood parasites that occur in grouse, two have been found to be of major pathological importance and latterly the investigation has been confined to these, although recently expanded slightly in personnel in order to make more rapid progress. An entomologist is being supported during his graduate training in the University of Toronto, and this summer we maintained a small field party in Algonquin Park studying both birds and insects. It was a productive effort and has provided problems and material for our winter work.

This investigation has been conducted with the full approbation of those interested in wild life. It is duplicated by no other organization. Our parasitologist acts also as part-time lecturer in Parasitology at the University of Toronto and we know of no other specialist in this field in the Toronto area. His services are called upon by hospitals and also by government departments responsible for the maintenance of food standards.

Physiography

Since 1935, the Foundation has conducted an annual programme of soil surveys which has covered all of the agricultural areas of Southern Ontario. All the main soil types have been identified and mapped and related to such factors as topographic form, geological origin, depth to bedrock, etc. Prior to the undertaking of this work there was no available systematic knowledge of Ontario soils. The results of this great task will be published in the not distant future.

The materials of this basic study are of interest to many organizations requiring accurate knowledge of our soils, including the Ontario Departments of Agriculture, Highways and Lands and Forests. Requests are being received for similar information concerning sections of Northern Ontario. All parties interested in the work have urged that it be completed and published in a form that will be useful in applied fields and for educational work.

The projects in Parasitology and Physography have been voluntarily carried by the Foundation since 1934. with a portion of the income arising from its invested funds. The Foundation has been happy to conduct them (a) as worthwhile contributions to scientific knowledge, and (b) as a service to the community.

It is now becoming increasingly important that the support of such projects is producing a strain on the Foundation in the light of its obligations to the larger field of industrial research. Reference has already been made to lowered investment income and advanced research costs. These have combined to curtail seriously the volume of independent research which the Foundation is able to conduct. Such research is imperative if the Foundation is to be scientifically strong. It must keep ahead of the demand for industrial services. The importance of these considerations will be evident when it is realized that the majority of the Fellowship Projects now being conducted at the Foundation have been entrusted to it because basic work on the subjects concerned was done in the laboratories during the 1930's. It is no longer financially possible to follow this practice. The ultimate outcome of the existing situation, if allowed to continue, will be that the Foundation's usefulness to the industrial community and its scientific status will alike suffer. A high standard of scientific services cannot long be rendered on a hand-to-mouth basis.

The Foundation is accordingly faced with the alternative of withdrawing with reluctance from the fields of Parasitology and Physiography or obtaining the support of the Province for their continuance. Figures showing the cost of such support are given later in this brief.

Industrial Investigations

Since its establishment in 1928 the industrial activities of the Foundation have been concentrated in the fields of Biochemistry, Chemistry, Metallurgy and Textiles. This has been a natural development, since it is largely in these spheres that opportunities have existed for the assistance of industry. Staff and facilities have accordingly been provided to meet the type of demand that has been met in actual contact with industrial units.

In more recent years it has been apparent that scientific investigation is warranted in certain fields which the Foundation is not now equipped to serve. In certain of these in which the public interest is concerned, the Foundation could by reason of its facilities and experience make a worth-while scientific contribution. It is not able to do so because of its limited resources.

The following instances are typical of the projects which are of first importance in the economy of the Province and in which research is abundantly warranted,

1. Industrial Utilitzation of Agricultural Products

Anything which will contribute to the stability of the demand for agricultural products or to the utilization of wasted by-products will make for the betterment

of agricultural prosperity. For many years effective agricultural research has been conducted in Canada in regard to production. We are not abreast of the times with respect to utilization. Some members of the Commission may know something of the development of what has come to be known as Chemurgy in the United States. I refer to one fact only, the establishment of four regional laboratories, each with a Federal grant of one million dollars per annum to investigate the industrial possibilities of agricultural products. With these laboratories we are already in close contact and we should be equipped at least with the manpower and facilities to explore the potentialities of their work in terms of Canadian materials and conditions.

Below are given a number of significant avenues for research activity of this type:

(a) Industrial Chemicals. Farm products are extensively used in other countries for the production of solvents, protective coatings, acoustic materials, polymers, etc. There is no doubt that effective work in this field would enlarge the market for farm products and provide new industrial materials which could take the place of imported supplies.

(b) Vegetable Oils. Experience during and since the war has shown how dependent we are on imported sources of vegetable oil. The Foundation has gained much valuable experience in the oils and fats field which could be usefully and profitably employed in further investigation of the subject.

(c) Dairy By-Products. Many interesting applications of dairy by-products have been developed recently, especially in the pharmaceutical, food and chemical industries. Whey is still the outstanding example of a material having only a very limited use. Many other products of dairy origin which are now imported could be made here if their technology were better understood.

(d) Plastics, Plastics are derived from many basic materials but they are still relatively expensive in relation to the competitive use of metals and wood. The search for a cheap plastic base therefore goes on. Perhaps an agricultural source may provide the solution.

The foregoing are representative phases of useful headings under which research could be profitably pursued on behalf of Ontario. It is not proposed that all should necessarily be undertaken but rather that a beginning should be made on whatever may be regarded, after due consultation, as being of greatest importance.

2. Wood Chemistry

Forests are the source of a substantial portion of Ontario's productive enterprise. The utilization of forest resources is attended by considerable waste, a good deal of which should be recovered if only economic methods were known. The potentialities are promising for the development of secondary industries on the basis of such recoveries and this is significant indeed from the viewpoint of the economic and industrial stability of Northern Ontario. If time permitted I would have referred in greater detail to the research facilities of this general character which are available to our competitors in Russia, the United States and Sweden.

The Foundation has gained a volume of scientific knowledge and experience through actual work in this field. It would seem both logical and desirable to use this groundwork as a base for needed extension to our technology.

3. Low Grade Ores.

There are in Northern Ontario millions of tons of low grade iron ores which at present cannot compete with imported ores or with limited high-grade Ontario deposits. The economic possibilities of employing this ore in conjunction with low-cost electric power, warrant serious consideration of investigating new approaches to its use.

Research of this kind would naturally entail a working combination of the electrical background of the Hydro-Electric Power Commission and the metallurgical resources of the Foundation. The work could readily be arranged to include the recovery of titanium which occurs with the iron in the deposits mentioned and is rapidly growing in economic importance. Favourable results in this field would likewise have an important bearing on the future economy of the northern part of the Province.

4. Mine Safety

We have already received a request from the Commission to undertake an investigation into the causes of corrosion in mine ropes during service, and it will be a privilege to be associated with this important work. My colleagues go further and stress the importance of a clearer understanding of the characteristics of the wire from which rope is made. This foundation is equipped to investigate the effects of stress on the magnetic and electrical properties of wires of various compositions and possessing differing elastic and plastic properties. These two fields of research are essential if we are to make a worth-while contribution to the safety and efficiency factors of the great mining industry of northern Ontario. Our recommendation is that both should be authorized and supported by the Government.

Cost of Projects

Prosecution of the investigations to which we have referred would entail outlays for (a) Staff, (b) Equipment, and (c) Accommodation and General Expenses. The following is an attempt to approximate such outlays during the first year of operations.

	Parasitology	Physiography	Agricultural Products	Wood Chemistry	Iron Ores	Mine Cable
Number of Graduate Personnel Required	3	3½	2	2	2	2
Number of Laboratory Assistants Required	1½	..	..	2	1	2
Cost of Personnel	$13,000	$10,400	$12,000	$12,000	$9,000	$12,000
Outlay for Equipment and Supplies	2,000	2,100	2,000	2,000	10,000	2,000
Accommodation and General Expenses	7,000	5,000	6,000	6,000	5,000	6,000
	$22,000	$17,000	$20,000	$20,000	$24,000	$20,000

Total of Above Projects	$123,500
Less: Amount Already Paid for Climatology Work	2,400
	$121,100

The above figures are for one year only. It would be desirable indeed if government finances could be arranged to provide for research commitments

over a period of years as the researches indicated are all of a type which will require a number of years to complete. In this connection it should be mentioned that in Great Britain the Department of Scientific and Industrial Research provides grants for industrial research which run for four and five years. We hardly need point out to the Ontario Research Commission the difficulty of interesting scientific workers of a high type in long-term projects for which support is not assured beyond one year.

It will be realized that if these proposals are favourably regarded for active investigation during the 1947-1948 fiscal year, time will be required to obtain staff, accommodation and a certain amount of equipment. It is therefore desirable that the Foundation be informed at the earliest possible date as to whether support will be forthcoming for all or part of the proposals. No project authorized by this Commission and the Government will be started or continued without the background of essentials in personnel and facilities. Our interest is in productive research not in the size of our physical equipment or annual expenditure.

Conclusion

It is the ardent hope of the Foundation that the co-operative arrangements which enabled good investigational work to be done for the Government of Ontario in the years 1929-34, may be resumed. The relationships which existed during that period placed the Foundation in a position to conduct government projects under satisfactory conditions which in turn permitted it to give sound value for the public funds expended.

The industrial economy of the Province is clearly becoming increasingly involved in the application of technology to its operations. The demands for scientific assistance are greater even than in wartime and the peak is not yet in sight. Of the institutions which undertake research, the Ontario Research Foundation is ideally fitted to serve the industrial community of the Provicne. On the basis of its past record and future potentialities, the Foundation is gearing itself to serve a broader field and needs adequate support on that account. As a contribution to industrial research in the key industrial province of the nation, the annual expenditure involved is comparatively small.

At a later meeting held on November 30th, and at the request of the Commission, the following additional statement was presented by the Foundation.

Extension Service

The Board of the Ontario Research Foundation is prepared to accept the invitation of the Research Commission to provide facilities for extension work among the industrial units of Ontario, if the following conditions can be met:

(1) We believe that such work to be effective should be undertaken by competent people working adjacent to and in close co-operation with the senior scientific staff on the Foundation.

(2) Neither our present nor immediate future building space can accommodate this unit, and we must ask for the co-operation of this Commission in securing the necessary offices. Immediately to the south of our property the house, known as the White property, is occupied by the Provincial Fire Marshal. For many reasons we feel that this house is ideal for this purpose. Some such property, in our immediate neighbourhood, is definitely vital to the plan.

(3) Without going into detail at this stage we offer the following suggestions in regard to staff. The success of the work will largely depend on the person selected to organize and direct the work. Furthermore, we stress the importance of associating with him two or three competent young men who will spend a considerable portion of their time in establishing and maintaining personal contact with industrial plants. No service of this character without intelligent follow-up can be efficient. My Board is not in a position to give any detailed estimate of what these facilities will cost, but assuming that the property mentioned is made available, they consider that a budget of **$40,000** for the first year's operations should be considered and approved by this Commission and forwarded to the Government.

We would emphasize that any plan of this nature would supplement and not be competitive with the activities of the Federal Departments and the National Research Council.

I would define the objectives of this Department as follows:

(a) To secure from all available sources pertinent scientific and technical information.

(b) To correlate the same and to present it in intelligible form.

(c) To cultivate directly and indirectly interest in scientific method and scientific research.

(d) The interests of the enquirer must always come first.

Group Research

It is generally agreed that applied scientific research cannot be undertaken by the typical smaller manufacturer. Research Associations in England have by groups gone far toward the solution of this problem by supporting laboratory work in their own interest, but with some help from the Government. Generally speaking, in England the Government has paid about one-third of the bill. We believe that here in Ontario an experiment should be conducted to see whether members of the same industry may be associated together in the support of a research programme, whether this be done by independent facilities or in Ontario Research Foundation laboratories. We are willing to work this out on an experimental basis by making a start on a modest scale in an effort to establish the soundness of the principle involved. Past experience has shown that success will depend partly on whether or not the Government is willing to share in the expense involved, particularly in the initial stages. The plan cannot succeed on a "cash and carry" basis. We recommend that a sum of **$25,000** be earmarked for limited amounts of experimental work in this important field, to be used during the calendar year of 1947.

We regard the two projects which we have outlined as essential components of an overall project, namely, a combined effort on the part of Government and industry, working through the Foundation, to assist the smaller industrial units in raising scientific and technical standards throughout the Province. There is a concensus of opinion that an instrument of this type is absolutely essential.

BUDGET

Extension Service: 1947-48	$40,000.00
Group Research: 1947-48	25,000.00
	$65,000.00

COMMITTEE ON SOILS RESEARCH

Meetings—

Informal	Nov. 2nd, 1945	Ontario Research Foundation Library
Joint Meeting with Ontario Research Commission	Nov. 14th, 1945	Ontario Research Foundation Library
Advisory Committee	Apr. 4th, 1946	Ontario Research Foundation Conference Room
	July 3rd, 1946	Faculty Lounge, Ontario Agricultural College
	Sept. 23rd, 1946	Horticultural Experimental Station, Vineland

Committee—

Dr. H. B. Speakman	Ontario Research Foundation
Prof. G. H. Ruhnke	Ontario Agricultural College
Prof. F. F. Morwick	Ontario Agricultural College
Mr. J. Walters	Department of Highways
Mr. A. H. Richardson	Planning and Development
Mr. R. N. Johnston	Lands and Forests
Mr. G. A. Hills	Lands and Forests
Prof. D. F. Putnam	University of Toronto, Geography Department
Mr. L. J. Chapman	Ontario Research Foundation
Prof. R. F. Leggett	University of Toronto
Dr. A. Leahey	Department of Agriculture, Ottawa
Prof. E. F. Palmer	Horticultural Experimental Station, Vineland

SOILS RESEARCH IN ONTARIO

Interested Groups

Perhaps in no other field is there a greater need for a co-ordinated long-term programme than in the field of soils. Soils are of vital concern to Agriculture, and that concern is reflected in the activities of the Dominion and Provincial Departments of Agriculture. Soils data are key factors, and are recognized as such, in the work of the Ontario Department of Lands and Forests, the Ontario Department of Planning and Development, and the Ontario Department of Highways. Information on soils is of assistance to the Department of Mines and to those charged with the administration of game and fisheries. The work of the Ontario Research Foundation on Physiography and Climatology would be much more useful in an intelligent land-use programme if correlated with an accurate and complete study of the soils in the Province, while such a study would be of tremendous value to educational groups in the teaching of geography. The importance of soils in the general economy is further evidenced by the recent setting up of the Associate Committee on Soil Physics within the National Research Council.

That each of the interested groups has done valuable work in this field is a matter of record; that there has been little, if any, duplication is rather amazing.

This situation is due, no doubt, to the splendid co-operation which has existed. There is every reason to expect that the various groups would continue the present practice of mutual help and understanding, but, with the growing need for the immediate extension of our knowledge of soils throughout the whole province, there can be no doubt that a programme, planned and carried out by all, would not only meet the needs of each much more rapidly, but would do it at considerable financial saving over a period of years.

The necessity for some planning and direction of proposed research on soils may best be emphasized by a summary of what each of the interested groups has been and is doing, and what each considers must be done. Only a general statement is included here. More complete detail is given in the attached appendices.

Dominion Department of Agriculture

The prominent place that Agriculture has occupied in the economy of the Dominion accounts for the fact that there has been, in comparison with other industries, a continuous and considerable programme of research and development, the latter usually taking the form more generally known as extension work. The Department has done, for some years, work on soil surveys in co-operation with the Ontario Agricultural College. Various stations are maintained throughout the province and at these work with reference to soils and soil fertility is done. It is hoped that, in conjunction with the Ontario Agricultural College, the study of fertility requirements and crop adaptation of various soil types will be developed. The Science Service Division does work of two types—(a) service work in co-operation with the Experimental Farm Service, and (b) purely research undertakings. Soils samples, collected from various parts of the Province, in soils survey projects, are analyzed, and chemical analyses in connection with soil erosion and the use of fertilizers are made. Chemical studies and tests of soils in regard to apple culture are carried on, and included in their research are the studies of soils colloids and their relation to soil fertility, the problems of forest fixation and some investigations of soil organic matter. Methods of determining plant food requirements have been explored and the question of the role of minor elements in soils have been studied. Extension of the work is planned as soon as personnel is available, and there is no doubt that many of the Department's activities would fit into a larger research programme.

Ontario Department of Agriculture and the Ontario Agricultural College

In this report no attempt is made to differentiate between the Ontario Department of Agriculture and the Ontario Agricultural College. Their association is so intimate that they will be treated as one, and any reference to either implies the interest and assistance of the other.

The position occupied by the Ontario Agricultural College in the development of agriculture in the Province and the contributions it has made to that industry are well-known to all. For our purpose it will be sufficient to mention some of its work and plans in the matter of soils, and to stress again the co-operation which has existed between it, the Federal Department of Agriculture, the Ontario Research Foundation, and the other groups interested in soil research. The first claim on the staff of the College is, of course, the responsibility for teaching the students, but they have made and will make singular contributions in the matter of soils. The major project which is commanding the interest of

the College is that of Soils Survey. Many counties have been mapped, and further work along this line will be done as soon as personnel is available. This mapping has been supplemented by considerable laboratory work on the study of soil types, but the College itself feels that there is still a need for chemical and physical investigations of the soils mapped, to provide fundamental information in connection with problems of soil fertility and soil conservation. In addition, a good deal more work on forest fixation, soil colloids and soil fertility should be undertaken.

An extensive programme of co-operative field experiments has been initiated on selected farms where the effects of various fertilizers, the amounts required, and the best method of application, as reflected by crop response, are studied, and these experiments are supplemented by laboratory research. The demonstration plots, at which field meetings are held, are of tremendous value in teaching soil management to farmers.

A Soil Advisory Service is maintained at the College, where each year some four thousand soil samples are tested for farmers and fruit growers. In this connection much useful information is obtained from the questionnaire which the applicant is required to complete. Further limited tests are provided by County agricultural representatives equipped with field kits. At the present time a programme to assist in soil conservation is being developed. The plan is that a farm will be mapped in respect to its soil types, and a complete scheme for the best use of the land and for soil conservation, under a system of cropping and rotation best suited to the needs and potentialities of the farm, will be worked out. The business management of the farm will, of course, be left to the farmer concerned. (See page 46.)

Ontario Department of Lands and Forests

Since this department is concerned with the sale of public lands and the management of forests, it is interested in soils surveys for the purpose of determining (a) the relation between soil type and forest growth, (b) which regions should be opened for agriculture, and (c) which should be maintained as forest or planted to forest. The northern clay belt is the region of major concern at the moment, and accurate soil information is required to prevent the improper assignment of sections of this region for purposes of settlement. On the other hand complete information in regard to soils would enable the Department to undertake an intelligent programme of land reclamation in regions of muskeg and in regions swept by fire. Moreover, since soil fertility is a definite factor in the welfare of fish, it is a matter of concern to those charged with the proper management of our fisheries. (See page 70.)

Ontario Department of Planning and Development

The Conservation Branch of this Department is interested in river valley development which has to do with soil conservation, forestry, erosion, water conservation, flood control, underground water and land-use. The project in the Thames River Valley area, where the land has been classified on the basis of its use capabilities, and the soil types, erosion, and slope have been mapped, is a typical example of what form the work of the Department will take. (See page 54.)

Ontario Department of Mines

In Southern Ontario considerable work has been done on ground water and its relation to the problem of soils. Much remains to be done. The work of

preparing a uniform system of logs to be followed by well drillers is an example of an undertaking which is incomplete.

Ontario Department of Highways

The importance of soils in the matter of highway construction has led to the establishment, within the Department, of a soils division. Its purpose is to provide information as to the soils over and through which the highways will run, with a view to assessing such factors as compaction, the presence of frost-heave material, the depth of the water table below the surface, the type and thickness of the base course required, and the type of materials which should be used in the construction of the road. Consideration of these factors is essential to ensure stable foundations which are obviously necessary for any degree of permanence. County soil maps are used as a preliminary guide for a much more detailed strip map, and the type of classification used is identical with that used by the other groups doing soil survey work. (See page 57.)

Ontario Research Foundation

The initial interest of the Ontario Research Foundation was in crop adaptation, and this led directly into the problems of soils classification and climatic conditions. A vast amount of work on climatology has been done, the value of which would be greatly enhanced by a complete survey of soils. The correlation of climate and soils would make possible a much more reliable basis for proper development of forests and farm lands, and the Foundation is in agreement with the other groups that the most urgent need is the completion of soils surveys throughout the Province. (See pages 59.)

ADVISORY COMMITTEE ON SOILS

It is apparent, then, that there is every opportunity for mutual help and co-ordinated effort on the part of the various groups concerned with the problem of soils. How best this can be promoted, keeping in mind the needs of each, together with their facilities and personnel, remains to be considered. Recommendations to this end are respectfully submitted.

Suggested Recommendations

For Co-ordination and Direction of Soils Research:

(a) The establishment, on a permanent basis, of a central organization to co-ordinate a general programme of research for the Province, and to advise the Government thereon.

(b) The establishment, by this organization, of an Advisory Committee on Soils.

(1) to submit plans for the co-ordination of all Soils Research in the Province.

(2) to submit estimates of the cost of the suggested programme.

(3) to correlate the data arising out of this research, for submission to the central organization.

(4) to advise the central organization on all matters pertaining to Soils Research, including such considerations as personnel, scholarships and fellowships, publications, etc.

Projects—General:

(1) The establishment of more extensive fellowships and scholarships to attract students to the field of Soils, with a view to correcting the present deficiency of qualified personnel in this field.

(2) Renewal and extension of the programme of Soils survey, with a view to the complete mapping of the Province at the earliest date possible, and recognizing the particular urgency of the study of the soils in the northern clay belt.

(3) Assistance to permit an expansion of activities in the fields of Climatology and Physiography, and the correlation of existing data in these studies with the data obtained in Soils Surveys.

(4) The expansion of the programme of the mapping and land-use direction of individual farms.

(5) The encouragement of the co-operative study of fertility requirements and crop adaptation of various soil typs.

(6) Extension of the work on forest fixation, soils colloids and soil fertility.

(7) Extension and encouragement of the work of river-valley development.

(8) Provision for the inauguration of a programme of waste-land reclamation and forest regeneration based on accurate information regarding the soils in the areas concerned.

Projects—Special:

The projects listed below have been selected because they involve fundamental problems bearing upon ultimate land use, and because, at the present time, no systematic large-scale work is being done on any one of them.

Some of these projects offer an excellent medium for co-operative research on the part of two or more institutions or departments, and can be broken down readily into sub-projects suitable for post-graduate students in several fields.

1. Physico-Chemical properties of Ontario soils affecting the erodability of important soil types.

2. A study of the physical, chemical and mineralogical character of the clays in the major soil types.

3. A study of water-borne sediments and soil nutrients in rivers as a measure of soil erosion losses from a watershed.

4. The rate of infiltration of rainfall into soils as related to run-off.

5. The distribution of cobalt, manganese and iodine in soils and crop plants in relation to the incidence of deficiency diseases in livestock.

6. An investigation of the sulphur content of the precipitation in various localities in relation to sulphur additions to the soil.

THE DEPARTMENT OF SOILS—ONTARIO AGRICULTURAL COLLEGE

Professor G. N. Ruhnke—Ontario Agricultural College

The Department of Soils in co-operation with other departments of the Ontario Agricultural College, such as Agronomy, Horticulture, Drainage and Agricultural Engineering, and with the co-operation of the Dominion Experimental Farms Service, proposes to assume the responsibility for dealing with the problems of classification, mapping, utilization, management and conservation of farm soils in the agricultural areas of the Province.

The Department does not propose to initiate surveys or investigations of forest soils problems, of problems of soil mechanics or of problems related to the location or construction of highways, dams, airports, and etc., but will co-operate in providing information from soil surveys or others of its projects, of assistance in dealing with such problems.

The Department of Soils proposes to continue and to develop its programme as follows,—

1. Soil Surveys

(a) Complete as rapidly as possible the preparation and publication of maps and reports for the counties surveyed but not yet covered by publications.

(b) Complete as rapidly as possible the classification and mapping of the soils of agricultural areas in the remaining unsurveyed counties in Southern Ontario and in the districts of Northern Ontario.

(c) As soon as the extension to the present Soils Building is completed and additional laboratory facilities are available, the Department proposes to expand its programme of fundamental research in the study of soil types and their characteristics, as they relate to land use, erosion control and soil conservation.

2. Soil Fertility Investigations

It is recognized that the maintenance of the organic matter and the fertility of the soil, are basic to other measures for restoring the productivity of run-down or depleted arable lands. These problems involve the type of farming, system of cropping, and the characteristics of the soil type.

By means of correlated laboratory studies, pot cultures, and field experiments, it is proposed to continue and expand the investigations of the use of lime, fertilizers, manures, crop residues and other soil amendments for fertility maintenance and crop production.

3. Individual Farm Surveys for Soil Conservation

The Department is developing a farm planning service for soil conservation, to make individual farm surveys, prepare plans for the farmer, and direct the initiation of the recommended conservation practices on the planned farms.

Until a larger staff of trained personnel is available this service is being concentrated on typical farms selected spceifically for demonstration projects, by County Agricultural Committees and the County Agricultural Representatives as a part of the County Soils Programme.

The Agricultural Committee and the Agricultural Representative take the responsibility for selecting the farmer and the farm, where there is assurance that the plan for land-use adjustment and soil conservation practices worked out for the farm will be put into operation without delay. The Committee is expected also to maintain an active interest in the demonstration and give encouragement and assistance to the operator of the farm in carrying out the recommendations. These demonstrations are intended to show how an integrated plan of land-use, soil conservation practices, and good farm management can benefit the farmer and the farm.

As a part of the local educational programme on soils, the County Committees are expected to hold field meetings on these demonstration farms when established, so that other farmers and the public generally may see what is being done in a practical way to promote soil conservation.

It is intended to expand the farm planning service as rapidly as possible, in relation to the demand, so that the service will be available to any farmer who desires it and is interested in undertaking a co-ordinated programme for soil conservation on his farm.

4. Investigation of Erosion on Cropland

It is proposed to undertake studies of losses of soil and water by run off, on selected sites, having regard for soil type, slope, crop rotation, etc., to provide local data for use in connection with the farm planning service.

5. Training Personnel for Soils Work

The Department recognizes the serious lack of soil surveyors and other soils specialists at the present time and the urgent call for trained personnel to adequately staff its own organization, as well as those of the other co-operating agencies engaged in soils work in this Province.

To help to meet this need, provision is being made in the new Department for more adequate organization and facilities for graduate instruction and research. Further, it is intended to establish at the earliest possible time, a Soils Option in the third and fourth years of the Degree Course in Agriculture, to give more encouragement to students to proceed to specialize in some phase of Soil Science in post-graduate study.

Technical short courses of instruction for basic training in soil survey and farm planning techniques will be given also, as soon as the present staff of the Soils Department is increased sufficiently to take care of the current programme of teaching, surveys, experimental work and service work, and make possible taking on additional commitments.

RESEARCH DIVISION—DEPARTMENT OF LANDS AND FORESTS

R. N. Johnston—Research Division

The soils research programme of the Department of Lands and Forests is determined by the administrative functions of the Department. These are:

1. The sale of public lands.
2. The management of public forests.

The area involved amounts to some hundred million acres south of the Albany River and some fifty million north of this line in the District of Patricia.

Governing factors in this programme are:

I. (a) A provincial soils inventory and analysis of soil classes on the basis of inherent soil values.

Using this information, the Department can intelligently segregate farm and forest lands on the basis of estimated financial returns.

(b) Set up forest uses of forest soils which will secure the maximum yield without depletion of soil values.
This will secure settled and permanent conditions in wood using industries.

II. Short Term Objectives

(a) The early completion of a soils survey of crown lands adjacent to developing farm communities.

This information is related to a sound postwar settlement scheme and is the Department's priority soils research project.

(b) The establishment of a soils research laboratory.

Soils laboratory services are required to complete any soils survey. Such a laboratory should be competent to cover the physical, chemical and biological factors of soil value. Detailed knowledge of Ontario's forest soils is practically non-existent.

III. Proposed Expansion

Perhaps the most important soils problem in the Province is concerned with the Northern Clay Belt bordering James and Hudson Bays. At least 20,000 square miles in this tract are at present covered by a barren muskeg, apparently the result of a degrading combination of climate and drainage.

Properly developed, this blank area, and a tract of poor forest land bordering it of equal or greater extent, could almost certainly be converted to a productive forest area, could probably become good grazing land and might possibly develop suitable conditions for general farming.

The realization of this soils productive capacity along any of the three lines indicated above, or as any combination of them, should have a decided effect on the economy of the Province. If and when funds are available, the Department plans to investigate this problem.

In view of the above, it is, therefore, suggested that:

(1) The Department will require $50,000 annually in addition to present expenditures, to carry Items I and II above at maximum speed for the next five-year period.

(2) An additional $50,000 should be available for an initial experiment in the improvement of Clay Belt soils. This sum is required to cover one season's field work and studies of results obtained.

Signed: "R. N. JOHNSTON",
Approved: "F. A. MACDOUGALL". Chief, Division of Research.

ANNUAL OUTLAY FOR FIVE-YEAR PLAN

Salaries	$27,200 – $36,200
Travelling Expenses	7,000 – 10,900
Maintenance	3,000 – 5,000
Publication of Maps and Reports	2,000 – 4,000
	$39,200 – $56,100

Initial Outlay

Laboratory and Greenhouse (at Richmond Hill Research Station)	$15,000 – $30,000

SOILS RESEARCH—DEPARTMENT OF LANDS AND FORESTS

G. A. Hills, Department of Lands and Forests

Soil research may be logically discussed under three headings, viz. (a) Inventory, (b) Detailed Analysis and (c) Interpretation. In simple words, soil research consists of finding out what soils there are and where they are, how they are put together, and how they can be used. Inventory involves the classification and mapping of soils and other related natural features of land. Inventory is taken by the soil survey, the physiographic survey, the groundwater survey, the land-use survey, etc. These agencies generally show the distribution pattern of land by use of maps. Then after a type or class is established and mapped, it is studied in detail from as many angles as possible, i.e., by chemical, physical and biological analysis, and by experimentation both under natural conditions and under such controls as are provided by greenhouses, culture chambers, etc. Then all the knowledge obtained during inventory and detailed analysis are put together in such a way that the characteristics of each class may be evaluated in terms of capability for some particular land-use. It is obvious that fundamental research is urgently needed to study soil characteristics regardless of use because it is impossible to anticipate all the relationships between characteristics and use before both have been thoroughly studied. It is, however, also true that in a field so little explored as soils, research must be tied in very closely with use in order that we may begin as soon as possible to solve some of the many pressing problems.

While the Department of Lands and Forests is concerned generally with the wise use of all forests and forest land in the Province, it is charged specifically with the sale of public lands and the management and sale of public forests. This means that the problems are chiefly those concerning Northern Ontario, which comprises over 80% of our land area, but which is "home" for only 10% of our population. It is true that forestry can also play an important part in planning and wise use of Southern Ontario lands, but since these lands are largely privately owned the work of the Department in this area can only be one of education, by giving advice and demonstrations.

What should be done with the crown lands of Northern Ontario? It is true that experience and research in land-use in the south will be of some help with this northern problem. But unless it is recognized that there are great differences in the two environments this will result in corresponding differences in land-use patterns the present confusion, which has arisen largely through a lack of appreciation of this very principle, will not be improved.

Take, for example, the disposition of land in the Greater Clay Belt. Recent reconnaissance surveys have shown that while most of the land may be developed for agricultural purposes, the cost of **clearing** and, in many cases **draining,** removing most of the peaty surface and, in general ameliorating the soil is greater than the individual settler can afford. The result is that in the process of developing a few scattered farming communities, over a million acres have been so man-handled that they are no longer attractive propositions for either agriculture or forestry. In view of this, it would seem that a large proportion of the Greater Clay Belt should, for the immediate future at least, be placed under a stable forestry economy, even though the potentiality of the lands

would indicate that, in time, they will be used for agriculture. There is little in the experience of developing Southern Ontario which will assist in planning an economy which will involve a multiple land-use; one in which forestry will play a leading role and which will provide for a gradual shift from forestry to agriculture as the need arises.

In order to provide a frame-work for the study of such an economy the Research Division of Lands and Forests placed, in 1945, a six-man party in the vicinity of the town of Cochrane to classify the land in areas lying just outside the present settlement but including areas cut over and abandoned by previous settlers. A similar study was made by a three-man party in the Lakehead area during 1944.

While much research is needed to determine ways and means of using the resources of soils and forests of this area to the best advantage, we do know that the proper development of these renewable resources is basic to stabilized settlement in the north. Since we have seen that private ownership of land limits the effectuation of what appears to be the wise use of certain areas in Southern Ontario it would appear advisable to guard against the alienation of large areas in Northern Ontario, which would be thus placed outside the jurisdiction of those conservation measures which could best provide for their proper utilization. This is the reason why, on the basis of reconnaissance surveys, a map has been prepared showing the general area in the Great Clay Belt region where the surface rights should not accompany the mining and mineral rights granted those staking mining claims. This does not mean that there is any desire to withhold land from legitimate use for agriculture, mining, or any other industry. It is merely to ensure that land will not be alienated for the purpose of timber exploitation, speculation, etc., which would interfere with a long term conservation programme. This is a responsibility of the utmost importance.

While the initiation of some form of forest management is urgent for the Clay Belts to assist in the stabilization of settlement there, it is no less important in the infinitely greater areas of poorer forested land belonging to the crown in the remainder of Northern Ontario. In fact, so great is the problem and the area involved, the Department of Lands and Forests is selecting a number of "management areas" upon which to concentrate to a large degree investigation of forest practices. Here, too, soils research is urgently needed.

The Department of Lands and Forests, therefore, requires an inventory of all lands which are or should come within the sphere of a forest economy, regardless of whether they are forested or not at the present time, and irrespective of their agricultural potential. The Department also requires a detailed analysis of the land classes of both settlement and forest management areas. It may appear to be immaterial who prepares the inventory or provides the analytical data as long as it is presented in such a way that it can be interpreted in terms of forest capabilities. Experience has shown, however, that inventory and analysis cannot be made adequately without the most thorough knowledge of the problem. For this reason it is essential that certain types of soil research be conducted within the various departments who have the power either to exploit, or to conserve, this most valuable resource. This does not preclude the possibility that a long-term programme of purely fundamental research might, in addition, be carried on most effectively by a research institution unhampered by immediate demands.

In order that inventory and detailed analytical research in soils be utilized to the best advantage, it is essential that the data obtained in those ways be interpreted so that it can be understood by those who are in any way involved in planning the use of forest lands. For example, the research division is responsible to two other divisions within the department of lands and forests for direction in soil interpretation, namely, The Division of Lands and Recreational Areas and the Division of Timber Management. It might be pointed out here that there has been little mention of the use of soil data in forest management —that is, the art of managing a forest crop, not necessarily in a plantation and hence not truly reforestation in its usual limited sense. The work of interpretation is done largely through integrating all the natural land qualities—soil, climate, etc., to form a land class and presenting this in terms of capability for a particular land-use. Correlated with this is the training of forest engineers, public land inspectors and other officials engaged in the development of a sound forest economy.

SUMMARY

The Department of Lands and Forests, charged with the sale of public lands and the management of public forests, has three distinct and related interests in soil research. These are inventory, detailed analysis and interpretation.

A. **Inventory** (the classification and mapping of soils and other features of land)

I. Inventories (soil surveys) are urgently needed as a basis for intelligent land sales. Post war settlement makes this a priority service at this time if tragic and disastrous mistakes which characterize similar schemes in the past are to be avoided.

II. Inventory of soils and other characteristics of forest sites are essential to the solution of problems of forest management.

B. **Detailed Research** (chemical, physical, and biological analysis in the laboratory experimentation in the field greenhouse and culture chamber).

(1) To obtain further information about the types which have been established and mapped under inventory.

(2) To conduct fundamental research, for example in soil genesis which is a background for all soil research.

(3) To investigate further soil and crop relationships with a view to a most comprehensive study of soil improvement, to secure better tree crops or to improve forest soils to the point where they may be fit for agricultural development.

The following examples do not exhaust the field of investigation.

(1) The amelioration of the poorly drained peat lands of the Northern Clay Belt through various methods of drainage, partial removal of peat, introduction of micro-organisms, fire and mechanical operations.

(2) The effect of applications of peat and other organic matter upon forest growth.

(3) The effect of fire on forest soil.

(4) The role played by bacteria, mycorrhiza, and other beneficial micro-organisms in the nutrition of forest species. NOTE:—In this aspect of soil research many of the forest soil problems are different to those of agricultural problems.

(5) The effect of applications of fertilizers and amendments to forest species with special application to forest nursery and plantation practices.

C. Interpretation

I. Establishment of land-use capability classes and other guides for forest settlement and forest management.

II. Instruction in the character and use of Ontario's forest lands.

The problems involved in the above outline of Departmental policy are fundamental and lie at the root of any progressive development of the Province as a whole. That this is so needs no laboured proof. The simple fact that less than ten per cent of the population of the Province occupies more than eighty per cent of provincial property should be sufficient. It would manifestly be unfair to claim that soils alone have slowed down the development of these new territories. Many factors have been at work, but certainly soils and soil-use are major, if not controlling, elements.

Nothing here stated is intended to belittle or divert support from the work carried out in old Ontario. Much still remains to be learned about these soils and their better use.

Nevertheless, the fact remains that the Province's overriding soil problems, both in respect to the area involved and to the present state of our knowledge, are in the soils of so-called New or Northern Ontario. It is felt, therefore, that any programme for soils study recommended to the Government of this Province, which does not recognize the urgent need of soil classification and soil research for the largely unknown soils of the northern parts of the Province, would fail to face up to one of the most urgent and potentially one of the most profitable fields of post war soils research.

A STATEMENT OF LAND USE INVESTIGATIONS CARRIED ON BY THE DEPARTMENT OF PLANNING AND DEVELOPMENT

A. H. Richardson, Department of Planning and Development

Preamble

The Department of Planning and Development is a Department of the Government for " . . . formulating plans . . . to develop the human and material resources of the Province", but is not intended to be an operating Department or one which will eventually carry out major construction works. One Division of this Department is Conservation, and this Division is charged with carrying out investigations in four fields, namely:

1. Land-use studies.
2. Hydraulic studies as they pertain particularly to the selecting of dam sites and controlling floods.
3. Forest investigations such as the care of existing farm woodlots, reforestation and particularly the rebuilding of wooded areas at the headwaters of streams.
4. Wildlife investigations and the planning for recreational facilities in Southern Ontario.

Besides the chief of the Division, four experts in the above types of work are now employed full time in the Conservation Branch. Assisting these are temporary field groups, the size of which depends on the amount and importance of the work to be done wherever surveys are undertaken.

The activities of the Conservation Branch up to the present have had to do with what we term river valley development, and by this is meant "the wise use of all the natural resources of a river valley for all the people living in that valley, for all time." In carrying out such surveys, the aim is to prepare a report, with necessary plans, which can be supplied to conservation authorities in Southern Ontario if and when such authorities are established under Bill No. 81, known as the Conservation Authorities Act. When such plans have been supplied it is presumed that the work of the Conservation Branch with respect to an individual river valley will cease, except that assistance will be given in interpreting the plans of the report and acting in a supervisory capacity as requested.

It will be seen from the above that the Conservation Branch is, therefore, carrying out the meaning of the name of the Department in planning for such projects, but does not contemplate the carrying on the works of construction to complete this, or to do any of the other types of work covered by the report.

In addition to the main types of work indicated above, the Department has also interested itself in ground water studies and during the past year a geologist was employed during the summer months investigating ground water conditions in Southern Ontario. A report on this will be released by the Department early in the new year.

The Department has also undertaken, with the co-operation of the Dominion Water Board, the establishing of 23 gauging stations on the important rivers in Southern Ontario, and these, together with the stations operated by the Board for its own use, and stations operated by them for the Ontario Hydro-Electric Commission, cover this problem for the important rivers of the Province.

This is a type of work which has not been done in Ontario heretofore on a large scale, and is very essential when planning protective dams or programmes of water control on rivers which have a serious flood problem.

Land-use Studies

Land-use Studies conducted by the Conservation Branch form a part of the larger programme indicated above in river valley surveys. In this connection it is not the intention of the Department to attempt to conduct a land-use survey of the whole river valley, as the staff employed by the Department is not large enough for this purpose, even though it were desirable to carry out such a programme. The plan is to select a small representative watershed on the river valley in question, and carry out a token or sample land-use survey which it is hoped will be indicative of the type of land-use which could be recommended for other parts of the whole river valley. For example, on the Thames River surveys which were conducted during 1946 at least five dam sites were selected, one of these being on Trout Creek just above the Town of St. Mary's. The area of the watershed above this point is approximately 65 square miles, and this was taken as a sample area as indicated above. The survey done on this area has as its purpose to classify all land primarily for agricultural purposes on the basis of use capabilities and to divide the land which is suitable for cultivation from that which is not. The method used was based on the use capability surveys developed by the United States Department of Agriculture Soil Conservation Service, and the classification of land was based on the following mapable qualities:

(a) Soil type.

(b) Slope.

(c) Erosion.

(d) Physical obstructions to cultivation, such as excessive stoniness.

The intensity of the survey is indicated by the fact that the average coverage for each pair of field men did not exceed 400 acres per day, or 200 acres per man per day. This degree of detail is essential if the information is to be used for farm planning, the logical end of such work.

It was hoped that in addition to the survey outlined above a few examples of farm planning would be established on this particular watershed so that farmers in the area could see the ultimate purpose in such planning. Unfortunately time did not permit this and, as is well known, the number of men capable of carrying out farm planning is extremely limited in Ontario.

In addition to the Trout Creek Area, another small watershed, namely, the North Branch Creek, comprising some 35 square miles was also surveyed in the same summer.

As indicated above, these two land-use surveys on the small watersheds are all that we contemplate doing in the Thames River Valley because it is our intention that with these surveys as a guide, that after the Conservation Authority is set up, it will ask for assistance in such work from the Ontario Department of Agriculture, or if necessity demands it, that it will set up its own land-use and farm planning division.

It will be readily seen from what has been stated thus far that the Department of Planning and Development has no intention of setting up a soils or land-use surveys division, but will plan to continue to carry out such token surveys because in the preparation of plans for complete river valley development, soils in most cases is the important item. If, in the future, assistance can be obtained from the Department of Agriculture or other agencies to carry out the token surveys, it would be in line with our method of operating to have these older established and better equipped Departments do this work for us. In the meantime, as this is impossible, we feel that it is very necessary in the preparation of plans for river valleys that land use surveys be included.

Recommendations

(a) Soil Maps

As soil types form the basis for land-use studies it is not only desirable but axiomatic that soil maps be prepared for those parts of the Province where river valley development surveys are contemplated. Therefore, it is urged that the soil surveys of all of Southern Ontario be completed as soon as possible.

(b) Use-Capability Tables

Use-capability tables are also basic for land-use studies, and before these can be prepared it is necessary to carry out investigations into relative fertility levels and tendency to erosion of the major soil types. We further recommend that such tables be prepared as soon as possible.

(c) Aerial Photographs

As mapping for land-use is now done entirely with the use of aerial photographs, it is important that such photographs be available where such work is contemplated. As the taking of these photographs depends somewhat on the vagaries of the weather, it would be desirable to have such photographs taken of all of Southern Ontario, so that these would be on hand when requests are received for surveys in any particular area.

SOIL RESEARCH IN THE DEPARTMENT OF HIGHWAYS

J. Walter, Department of Highways

Soil studies were started in 1939 when it became evident that construction and design procedures should be supplemented with basic soil data. Soil consciousness developed due to several factors, some of which may be briefly stated as follows:

(a) Constantly increasing traffic density and loads.

(b) Present-day public opinion and transportation needs demand the construction of all weather surfaces during the same year or the year following grading operations. This time interval will not permit natural densification of subgrades and embankments nor subgrade defects to be corrected.

(c) Modern grade and alignment requirements often involve deep cuts and high fills, which require special treatments.

(d) Limited funds for rapidly expanding highway systems have caused the officials to construct cheaper types of wearing surfaces. Consequently, greater emphasis has been placed on the bearing capacity of the subgrade to transmit the traffic loads rather than the wearing surfaces.

(e) Snow removal permits greater frost penetration which in turn causes spring break-ups in certain soil types.

Soil Classification

Prior to any type of soil classification it is absolutely essential to become thoroughly familiar with the glacial geology of the province. This data is a prerequisite of the highly detailed analysis required in highway construction.

Soil classification is essential in order to sort, compile and record the various characteristics of soils so as to accurately identify soils and to permit practical application of the information obtained. It is proposed to use both the U.S. Bureau of Roads classification, which deals with the physical properties, and the pedological classification as developed by the Department of Agriculture.

The county soil maps as prepared by the Department of Agriculture are used as a preliminary guide for a much more detailed strip map. Precisely the same type of classification is done as that performed by the Department of Agriculture. Using the pedological classification as a basis, typical samples of the various soil types are taken and tested in the laboratory for numerous physical properties, considerable emphasis being placed on soil mechanics. Correlation of the two above mentioned systems of soil classification provides a medium for transferring soil information, construction experience and subgrade behaviour from one area in the province to another.

Soil Data and Application

A comprehensive soil report is submitted to the design office entailing over 20 design features. To insure stable foundations, the basic requirements are:

(a) Location of the grade line at least 4 feet above the water table.

(b) Removal of frost heave material.

(c) Proper compaction of embankments and subgrades.

(d) Use of suitable materials.

(e) Type and thickness of base course required.

The strip map is traced on the road plan while the soil report is used by the design office in preparing the final plans.

During grading operations the soil engineer checks the subgrade for frost heave materials and unstable soils, locates the amount of tile drainage required and checks the suitability of embankments compaction.

Present Status

Due to lack of personnel during war time, immediate demands for routine supervision and testing of highway materials prevented full time work on soils. Apart from one extensive research project, the soils work has been confined to field observations and basic data and to immediate construction projects. The soils work has also been greatly restricted due to lack of personnel and laboratory facilities. A temporary laboratory has been established at the Lands and Forests Experimental Station at Maple. During the last 9 months, 6 soil engineers and 2 laboratory technicians have been engaged in full time work on soils

Proposed Program

(a) Advanced study of glacial geology and pedological classification of soils.

(b) Extensive study of the physical properties of soils with greatly enlarged laboratory facilities.

(c) Extensive study of aerial photographs as related to soil classification and an inventory of granular materials.

(d) Field and laboratory research of pavement behavior with the various soil types.

(e) Field and laboratory research of aggregates as related to durability and field performance of the various pavement types.

(f) Soil surveys of several hundred miles of highway.

The achievement of this program within a reasonable length of time depends primarily on the following:

(a) **Personnel**—Since trained soil engineers are not available and a suitable soils course is non-existent, prospective engineers must be trained by this Branch and by periodic consultation with the Ontario Research Foundation and the Soils Department of O.A.C. An additional 10 soils engineers will be required for next year's work. Ultimately it is proposed to have 3 soil engineers stationed at Toronto to supervise the work of 19 field soil engineers and several laboratory soil technicians.

(b) **Data**—Fortunately the data on glacial geology for southern Ontario has just been completed by the Ontario Research Foundation. This information will be of indispensable value to the Soils Branch.

Although a large number of counties have been mapped by the Department of Agriculture, an early completion of this work, together with soil reports is urgently required. Until all counties have been mapped and the data compiled, continued consultation is quite desirable.

The services of Messrs. Chapman and Morwick have been most generously rendered during the past year and it is hoped that the same splendid co-operation will be secured in the future.

REVIEW OF RESEARCH PROGRAM IN PHYSIOGRAPHY OF THE ONTARIO RESEARCH FOUNDATION

D. F. Putnam—University of Toronto

and

L. J. Chapman—Ontario Research Foundation

In 1930, Mr. T. D. Jarvis began a program of work in ecology, that is a study of crop adaptations in Ontario. The environment of plants consists of climate and soil and it is from this viewpoint that the Ontario Research Foundation has looked at the soils of the Province.

In attempting to become familiar with the major soil differences in this area, the want of information about the land forms and glacial or lacustrine deposits that are chiefly responsible for those differences was soon encountered; and since no other agency was tackling this physiographic work, the Ontario Research Foundation took it up and has carried it to a state of near completion for southern Ontario. A series of three articles have been written to appear in "Scientific Agriculture" which summarized the survey work and gave small-scale maps of the surface features. More recently a large map on the scale of four miles to the inch has been prepared as well as a text to go with it. This includes the detail that was omitted from the journal articles. It is mainly an account of the last glaciation, especially the step by step picture of the recession of the Wisconsin ice sheet. Without such an aid to memory it is hardly possible to grasp and retain a mental picture of the soils throughout the province, varied as they are. However, the topographic form of the surface and the kind of rocks making up the deposits are stressed because these are the traits that affect the soil.

When the survey was made in central Ontario none of the counties had been mapped by the regular soil survey from the Ontario Agricultural College. In eastern Ontario only one small county, Grenville, had been mapped, and for these two sections the main soil types were described and mapped on a small, highly generalized map. This information was also presented through the medium of Scientific Agriculture. The section west of the Niagara Escarpment was studied last and by this time fourteen of the local counties had been mapped by the Ontario Agricultural College soil surveyors. In view of this we have not proceeded to a general description of the soils for this third section of southern Ontario, leaving that to the Ontario Agricultural College.

It might be well to include in this memorandum a brief mention of the climatic research done by this department even though it is only complementary to a study of soil. By making an analysis of the records collected by the Dominion Meteorological Service a series of climatic maps and tables were prepared that have filled a gap in the knowledge of the conditions under which farmers work in the province. This was only completed for the part south of North Bay. A similar set of maps is compiled for northern Ontario but owing to a lack of familiarity with that part of the province, the account of its climate has not yet been written.

In view of the steady demand for the foregoing information about climate, it is urged that further work of a more detailed nature on climate for the use of crop ecologists could very profitably be undertaken.

Having made a complete survey of physiography on a certain scale of detail in southern Ontario, it now becomes necessary to make it available to anyone who can use it. The three published articles are bare summaries and the maps contained in them only very small. The publication of a bigger, detailed map with a full text and supplementary maps and illustrations is undoubtedly a primary need. Repeatedly, requests have been made for copies of the four-miles-to-the-inch map. Work towards having it printed has been stalled for over a year due to the wartime dearth of men and materials, but it is hoped that a start can be made on it soon.

The Foundation has always been willing to spend the time necessary to go into the field with members of government departments, who were directly interested in our maps and has received similar aid in turn by the soil surveyors under the Department of Agriculture. This fall a member of the staff spent three weeks with the soil specialists of the Highways Department because they asked for a first-hand interpretation of land forms and materials. The Departments who are most directly concerned are: (a) The Ontario Agricultural College (Department of Agriculture); (b) The County Representatives; (c) Department of Lands and Forests; (d) Department of Planning and Development;

Occasionally there have been inquiries from high school teachers for material on climate or glacial geology or soil. In fact it is expected that one of the widest uses to be made of this work will be made in high schools. Here again this development will wait on the publication of a monograph about it.

FUTURE PROGRAM OF ONTARIO RESEARCH FOUNDATION

L. J. Chapman—Ontario Research Foundation

During a recent conference it was agreed that our physiographic survey should cover Manitoulin Island, the main argument being that this would give full coverage of all the farming country south of the Pre-Cambrian rocks. At the same time representatives of the Department of Lands and Forests asked when similar work would be undertaken in northern Ontario.

As it stands at present the published accounts of physiography lack detail as to the composition of the soil-forming materials. They include only an estimate of the proportion of the various limestones, dolomites, shales and sandstones of glacial drift in southern Ontario and rock of Pre-Cambrian age, A mineralogical study of the glacial drift in southern Ontario would give a much clearer understanding of soil development. This would require a man with training in mineralogy and in the use of instruments for physical testing. It is specialized work not now being carried on in the province and would probably take several years to complete the study. A better understanding of the release of minerals from the solid particles to the soil solution would assist us in giving sound advice about soil management.

Our account of climate needs to be supplemented. The increasing demand for dividing the province into zones adapted for certain crops, of for specific varieties, requires the study of climatic phenomena having a special bearing on those crops. So far only average conditions have been defined and if possible the Ontario Research Foundation will proceed soon with a more detailed analysis of existing weather records. It may be that more recording stations similar to the one set up last year at Redickville will be asked of the Dominion Meteorological Service.

Supplementary studies of local variations due to the lay of the land might well be carried out. This is recommended as a good project for students in natural science or agriculture and we should like to secure the co-operation of the Department of Education.

A set of climatic maps has also been made for northern Ontario. However, due to the scarcity of long-time records, and more particularly to our personal unfamiliarity with that region, we have not seen fit to publish an account of climate for that part of the province. The maps are being kept for reference until these limitations can be overcome.

During the past thirteen years preliminary notes have been made of the trees and smaller plants found growing naturally on the various types of soil throughout southern Ontario. With the completion of the physiographic survey the correlation of plants and specific soil types has commanded more attention. Such work furthers that knowledge of the landscape which is needed in making maps of zones for specific crops. Incidentally, this botanical approach may lead to a very practical grouping of our soil types, which will be useful to the crop specialists. There is also the promise of finding some species naturally distributed which will serve to guide the agronomists in giving advice as to where cultivated varieties should or should not be grown,

To summarize, our future work may be listed as follows:—

(a) Finish physiographic and climatic study of soutiern Ontario and publish reports and maps,

(b) Extend the above to Manitoulin Island as soon as possible, and eventually to northern Ontario, particularly those areas in which the Department of Lands and Forests is directly concerned.

(c) Initiate and maintain an investigation of mineralogical composition of Ontario soil types.

(d) Continue study of the natural flora in relation to soil type.

With regard to staff: At present this work is carried on at The Foundation by one man assisted in the summer months by Professor Putnam. To make any speed with the above programme at least two additional men must be secured and given permanent employment. The additional cost would be around $10,000.

GRADUATE TRAINING AND AIDS, (SOILS)

*C. A. Rowles Ontario Agricultural College

I. Problem

In the opinion of the group which met November 2nd, 1945, to discuss soil research in Ontario, one of the most serious factors adversely affecting soil investigations at the present time is lack of adequately trained staff. An important problem to be faced therefore is how best to encourage more students to take specialized training in soils.

II. What is Involved in Soil Specialization

1. Soil is a colloidal complex consisting of minerals, living and dead organic material, water and air, therefore all students of soil must be thoroughly based in the natural sciences, notably Chemistry, Mathematics and Physics. The mineral fraction of soil is derived from the weathering of geological material, and students must also have some knowledge of Geology. In addition, some of the most fundamental soil reactions are due to micro-organisms and an understanding of Bacteriology is important. If the soil specialist is concerned with the soil as a medium for the growth of higher plants, it is essential that he have a knowledge of Botany, Plant Physiology and Agronomy. Students specializing in other phases of soils, such as Soil Mechanics, will require specialized study in other sciences.

2. Because soil science depends upon so many branches of study, the training of soil specialists presents considerable difficulty. It has been found that the undergraduate timetable is so filled with essential supporting classes that only the general fundamental principles of soil science can be included. Therefore specialization must usually be left for graduate study. This specialization may be in any one of a number of fields, such as soil classification and survey, land use planning, soil chemistry, soil physics, forest soils, etc.

III. Factors Responsible for the Problem

1. The meeting of November 2nd expressed the opinion that the shortage of soil specialists was primary due to four factors, as follows:—

(i) The growing demand for soil specialists in industry and various branches of government.

(ii) The lower salaries offered in soil science as compared to industry and other professions.

(iii) Lack of facilities for giving basic undergraduate training in soils.

(iv) Lack of facilities and encouragement for students to take specialized graduate training in soils.

2. The meeting felt that with the growing recognition of the importance of proper soil use, the increasing demand for soil specialists will continue, and it is hoped that this may lead to improved salaries. Therefore, our main concern should be with factors (iii) and (iv), undergraduate and graduate training.

3. The training of soil specalists has recently received special attention at the Ontario Agricultural College with the formation of a Soils Department. Additional laboratory space is under construction and consideration is being given to the introduction of a Soils Option. This should greatly stimulate undergraduate training in soils.

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*Now with University of British Columbia.

4. It is the opinion of the groups interested in soil research that special attention must also be given to the matter of encouraging students to take specialized graduate training in soils. These groups also believe that the most desirable and effective method of encouraging such specialized study would be to provide graduate fellowships for the use of students specializing in soils. Nothing at present is being done in this regard, and such fellowships would enable students to continue their studies and at the same time undertake research on soil problems important to the Province. There are many such problems to be undertaken, and the following are a few which could usefully be undertaken at the present time. Other important problems are included in the minutes of the November 2nd meeting. It should be noted that most soil problems require a certain amount of field work, which necessitates that allowance be made for travelling expenses.

(i) Study of soil properties in relation to run-off and soil erosion.

(ii) Study of the physical and chemical properties of specific soil types.

(iii) Study of classification, properties and use of organic soils for the improvement of mineral soils.

IV. Recommendations

In view of the considerations outlined above, it is recommended that:

1. Funds in the amount of $15,000 annually be made available for the granting of fellowships for special study and research on soil.

2. A special continuing committee be organized to deal with the selection of candidates, choice of research projects and allocation of funds. This committee should also be responsible for setting down details of the fellowship plan within the following general outline, which includes the three main groups of fellowships considered necessary.

(i) Five to eight fellowships in the amount of $500 to $600 annually, open to university graduates who have shown high academic ability and an aptitude for specialization in soils. The purpose of this group of fellowships would be to encourage the right type of student to compete for the Master's Degree at institutions in the Province. The fellowships should, therefore, be renewable for a second year, providing the student has shown satisfactory progress during the first year.

(ii) One or perhaps two fellowships in the amount of $700 to $1000 annually, open to holders of the Master's Degree in some branch of soil specialization. The purpose of this type of fellowship would be to encourage students of exceptional ability to compete for Doctor's Degrees. The fellowships should be renewable for a second year and the candidate should be allowed to take them up at any institution approved by the committee.

(iii) One or perhaps two research fellowships available annually to researchers in soils whose research makes it advisable that they go to some other institution for study or make use of special equipment in connection with their problem. This type of fellowship is extremely valuable in soil research and has not received sufficient attention in the past. The extent of the funds and time allotted to such projects should be left to the discretion of the Fellowship Committee.

(iv) Consideration should be given to special fellowships for veterans.

EDUCATIONAL MATERIALS IN THE FIELD OF SOIL SCIENCE

D. F. Putnam, Department of Geography, University of Toronto

Mr. Chairman and Members of the Ontario Research Commission:

You have been presented with many statements concerning the objectives, methods and results of Soil Research in Ontario; may I, at this time, place before you the importance of the educational phases of soil science. All scientific education is, and must be, based upon scientific investigation, hence we, as soil research workers, feel that a direct responsibility rests upon us to ask that proper educational material be provided for the interpretation of our findings to students at all levels. I suspect that it is our fault that such educational aids are lacking in our Province, and indeed in the whole country, but soil science in Canada is fairly young and we have been very busy laying its foundations. Perhaps I may add weight to my argument by pointing out that only this year has the Ontario Agricultural College, our oldest institution for the advanced study of agriculture, established an independent soils department; and only within the past five years at the University of Toronto has a course in Pedology been offered.

The educational point of view, however, embraces a wider vista than just instruction at university levels. The need is urgent also in the secondary schools, collegiates and vocational, in the public or primary schools and in that broad and rather informal field which we may term "adult education." Each of these fields requires special attention, each requires material prepared in accordance with its own educational objectives and couched in language understood by its own pupils. In a few words I propose to outline the situation in each of these cases.

I. The University Level

There is not in existence a Canadian textbook on soil science suitable for use in the classrooms of a university or agriculture college. All available texts have been written and published either in the U.S.A. or in Britain. Soil science may not be, and probably is not, alone in this unenviable position; nor do we ever hope to see the day when we shall, in sheer independence, disregard all texts produced in other lands. But, soil conditions are essentially geographical in their distribution and soil problems are distinctly local.

We, in Canada, are greatly interested in many questions which find no direct analogy in other parts of the world, save perhaps in the U.S.S.R. We need, therefore, Canadian college material for the teaching of soil science. At that, the university level is better served than any of the others, for many of our prominent soil scientists are teachers in our agricultural faculties. In those universities where agricultural faculties do not exist, most students, even in the natural sciences, graduate with very little knowledge of Canadian soil conditions. For biologists, whether their main interest be plants or animals, this is tragedy.

Therefore, apart from the prosecution and publication of all individual soil researches, be it urged that some thought be given to the preparation of a text which will emphasize Canadian problems and Canadian points of view.

II. The Secondary School Level

The need for instruction in soil science at the secondary school level has received much more recognition in recent years than in the past. There is still room for much improvement, however, for apart from five periods devoted to conservation in Grade IX, students in General Science get little instruction in soils. The sections devoted to soil in the general science textbooks are entirely inadequate and, in the expressed opinion of some members of this group, definitely misleading. Where agricultural science is taught, the situation is much better for, apart from the same five period course in conservation in Grade IX, the courses of study for Grades X, XI and XII prescribe at least fifty periods in which topics related to soils and soil fertility are discussed. In the opinion of some of us, this course rather puts the cart before the horse, since soil conservation can be much better understood after some of the fundamental facts have been mastered.

Wouldn't it surprise you to learn that in the lists of reference books which accompanies these courses of study there is not one relating specifically to soils?

There is, then, a very definite need for educational material at the secondary school level, based on the findings of our own research. That need is all the more compelling from the fact that few high school teachers have had much specialized training in soil science and hardly any at all have ever had research experience.

III. Public School Level

The further down the ladder of education, of course, the further we are removed from the direct impact of research findings upon educational materials; yet it is in the public schools, and particularly in Grades VII and VIII that many of the basic facts of science are first presented. Here, out of a book list which abounds in titles concerned with History, English, Mathematics, Shopwork, Home Economics, General Science, etc., there is none listed as specifically referring to the soil, which in the last analysis is the basis of our civilization. Hidden away under the title "Basic Science Education Series—several titles," there is one entitled **Soil,** but in order to find that out it is necessary to apply to the publisher! It is an excellent little pamphlet of some thirty-six pages—but its presentation is entirely American, and we need illustrations of Ontario conditions for Ontario pupils. Mention should perhaps be made here of Conservation Illustrated, published by the Canadian Nature Magazine, Toronto. It is a 32-page booklet containing ten short articles, one of which is entitled Soil. It is also crammed with illustrative drawings and photographs. But, even for public school levels this constitutes very inadequate source material for the teaching of soil knowledge—a knowledge which is a fundamental right of every citizen.

IV. The Field of Adult Education

This field is extremely broad, and its needs are as yet but vaguely understood. It is therefore somewhat difficult to suggest the form in which the results of soil research should be made available to workers and students in this field. I was much interested in a brief recently presented to the Commission on Education asking for the establishment of a **People's College** in Simcoe County. The objective of this institution was stated to be the teaching of the moral subjects, philosophy, history, etc.—the basis of civilization. Simcoe is also a county

which is much interested in its soils, and, in fact, the conservation of all of its natural resources. There is much that is moral, philosophical and historical in the study of soil resources and their exploitation.

In the field of adult education, then, there is a large and varied audience to which the story of soil science should be told and we feel that as soil research workers we have an interest in it.

In soil science, we are faced with an almost complete lack of teaching material at all educational levels, and it behooves us to enquire what should be done about it. Soil science, of course, has two phases: one, the application of fundamental physical and chemical principles; the other, being descriptive, geographical and illustrative. In elementary education, however, the two must be presented hand in hand. Now, it is popularly supposed to be the Province of the teacher to transmute scientific findings into teaching material; but since we have yet to teach the soils language to the teachers, we are going to have to supply not only the basic information but teaching application as well.

In so far as Ontario is concerned, we need, first and foremost, a general account of the soils of the Province, together with a map (or maps), which will summarize the results of the detailed surveys already made and anticipate the findings of those yet to be carried out. Such an account exists for Saskatchewan, making it comparatively easy to develop an understanding of the soils of that Province—at the University level at least. It is certainly much harder to present a connected picture of the soils of Ontario from a group of county maps and but two published reports. Such a report would fill an immediate need since at college levels technical bulletins are also teaching material.

There is not, I think, room for more than one good Canadian soils text; hence, its preparation should be the concern of all Canadian soils specialists. Regardless of who may write it, it should be edited by a committee of the soils section of the Agricultural Institute of Canada and should carry the approval of that body. The support of such a project by the Province of Ontario, is urged upon the Commission because of the need for such a book in Ontario, as well as in the rest of the country.

At the high school level, there should be at least one slim volume devoted to elementary soil science and its application to Ontario conditions. While the high school teaching profession and the Ontario Department of Education would probably have much to offer in the way of pedagogical suggestion, knowledge of the subject can only come from the soil scientist. We have yet to teach the teachers. One comment often heard at the present time is that the results of research are not being made available to those who need them. The results of soil research are certainly needed, and one of the best ways of ensuring circulation is to provide adequate teaching material.

At the public school level, we would urge that at least a booklet of the "unit reader" type be prepared to acquaint Ontario pupils with soil conditions.

All previous discussions have mentioned matters of time, funds, and personnel. The preparation of educational material is in this respect no different from any other project. Men must be assigned to the task, must become familiar with it and must carry it to a successful conclusion. While they are thus occupied, they will, perforce, not be fully active in the research field and an expansion of personnel will therefore be necessary. There are costs of publication also which must be paid out of public funds. In the case of textbooks, once demand is

established, there will probably be publishing houses willing to accept the responsibility, but the costs of bulletins and like teaching aids will have to come from the public purse.

I realize that I have mentioned many matters before this Commission which might almost equally well have been carried before the inquiry into education. I have tried to point out, however, that under present conditions the matter is almost inseparable from research itself. Moreover, there is no doubt in my mind, or in the minds of my colleagues, concerning the far-reaching importance of the educational phase of soils work. We therefore bring it to your attention and respectfully urge that it be given earnest consideration.

RECOMMENDED PROJECTS—SOILS RESEARCH—1947-48

Title	Agency	Capital	Operating	Total
Physiography	Ontario Research Foundation....	$2,100.00	$14,900.00	$17,000.0

COMMITTEE ON FISHERIES AND WILDLIFE RESEARCH

Meetings

Informal—Nov. 10th, 1945	Ontario Research Foundation Library
—Dec. 1st, 1945	" " " "
Advisory Committee—April 6th, 1946	Committee Room, No. 1, Parliament Buildings
—Aug. 19th, 1946	Queen's Biological Station, Chaffey's Locks, Ont.
—Oct. 5th, 1946	Royal Ontaro Museum
—Nov. 9th, 1946	Royal Ontario Museum

Committee

Dr. W. J. K. Harkness	Lands and Forests
Prof. A. E. Coventry	University of Toronto, Zoology Dept.
Dr. A. E. Warren	McMaster University
Dr. W. H. Johnson	University of Western Ontario
Dr. H. W. Curran	Queen's University
Dr. J. R. Dymond	Royal Ontario Museum of Zoology
Dr. A. M. Fallis	Ontario Research Foundation
Mr. H. H. MacKay	Lands and Forests
Dr. C. H. D. Clarke	Lands and Forests
Mr, K. M. Mayall	Planning and Development
Dr. A. O. Blackhurst	Federation of Commercial Fishermen
Mr. W. Austin Peters	Ontario Federation of Anglers and Hunters
Mr. Len Hughes	Ontario Tourist Trade Association
Dr. F. E. J. Fry	University of Toronto
Dr. R. R. Langford	University of Toronto
Dr. F. P. Ide	University of Toronto
Mr. E. C. Cross	Royal Ontario Museum
Mr. Lester Snyder	Royal Ontario Museum
Mr. T. C. McCall	Department of Travel and Publicity
Prof. C. E. Atwood	University of Toronto

FISHERIES AND WILDLIFE RESEARCH IN ONTARIO

General Position in the Economy of Ontario

Ontario's fisheries and wildlife are two resources which, while at present in the category of "wasting" resources, could be maintained at a reasonably permanent level. That they are important resources is generally accepted. It could not be otherwise, since ninety per cent of the Province is blessed with one or both of them, and fifty per cent of the Province will produce no other crop. They provide a direct annual income of some five million dollars a year to commercial fishermen and trappers, who are the primary producers for a number of secondary industries. They provide the chief attractions for the host of tourists who spend in the Province an estimated hundred million dollars a year, an expenditure which makes possible the employment of a number of people in direct catering, and which is the main support for the industries engaged in the manufacture of sporting equipment. Thus they represent an inexhaustible source of exports, provided we realize that Nature's beneficence is not unlimited, and that our privilege of exploiting these tremendous gifts involves the duty

of conserving them. Aside, too, from purely monetary considerations is the fact that they afford to many of our own citizens excellent facilities for recreation, a matter of considerable importance to general welfare.

Government Responsibility

The maintenance of these resources is, of course, left almost entirely to the Government. Since their nature is such that they are exploited for pleasure or for profit by thousands of individuals, no private groups or corporations are in a position to assume as much responsibility as they would where exploitation by a few might be directed by commercial common sense, with a view to permanence. Then, too, the Government derives from these resources revenues to the extent of approximately a million dollars a year, and, as the institution which enjoys the largest direct revenue, it is expected to be responsible for the proper husbanding of them.

Present Methods of Conservation

That that responsibility has been accepted is evidenced by the efforts of the Government to protect both fisheries and wildlife. There have been legal restrictions on the lengths of the hunting and fishing seasons, on the size and the number of the fish taken, and on the number of birds or animals shot. There has been complete protection for some species and there has been considerable re-stocking of game fish and birds. These efforts have modified the effects of too rapid "mining" of these two great resources, but are quite inadequate to provide a complete solution to the problem of constant depletion. They are inadequate, not because they are in themselves useless, but because other factors in the ecology of fish and wildlife—settlement, cultivation of the soil, deforestation, construction and destruction of dams, and the pollution of water with sewage and industrial wastes—may be detrimental to the purpose behind our present efforts. These other factors cannot be ignored and any comprehensive long-term programme aimed at correcting the basic causes of depletion must be based on adequate knowledge of all the favourable and unfavourable factors.

Present Situation

To date biological research is wholly inadequate to provide the information necessary for the proper administration of Ontario's fisheries and wildlife resources. As a matter of fact, aside from the collection of valuable data by the Royal Ontario Museum of Zoology over a period of years, there has been no systematic investigation of terrestrial wildlife in the Province. As a result our legislation and our practices have been based more on opinion than on scientific knowledge. The present bounty on "wolves" may be defeating its real purpose—that of deer protection—and it is not unlikely that agriculture may be paying a considerable penalty for our constant warfare against hawks, owls, skunks, weasels and foxes. Even the lowly forest mouse may provide an administrative riddle, for, while it is known to occupy a prominent place in the diet of our fur bearing animals, its depredations may be deterring forest regeneration or it may equally well be controlling some insect pests by eating their larvae.

While fisheries research is in a much happier position, historically, it is still too woefully inadequate to justify much confidence. We are still without reliable data concerning the capacity of waters to maintain a stock of fish, either as regards population or species, and we are without complete information regarding

the temperature and depth limits for all the various species. Moreover, there are tremendous gaps in our knowledge regarding the part soil fertility, deforestation, water pollution, etc., play in the ecology of the fish.

Existing Machinery for Research

There are in the Province sufficient institutions for the development of the comprehensive investigations essential to any successful approach to a programme of restoration and conservation. Each of the four universities offer much in the way of skilled help to direct research programmes and to assess the results. The Ontario Research Foundation and the Royal Ontario Museum of Zoology are in a position to make significant contributions, while the various Government Departments—Lands and Forests, Travel and Publicity, Health, Planning and Development, Tourists and Publicity—together with the Ontario Federation of Commercial Fishermen, the Ontario Federation of Anglers and Hunters, and the Ontario Tourist Trade Association, may all play a major part. In addition, the Great Lakes Fisheries Board, while outside the orbit of Provincial control will, no doubt, render invaluable assistance in its own field.

There is, then, no need for additional organizations to undertake a complete programme of research. What is required is that the efforts of existing institutions be co-ordinated and extended, so that the peculiar talents of each may be fitted most efficiently into an integrated Provincial programme. The universities, for instance, given the financal help required for extension of their facilities, are best suited to undertake projects of fundamental research, while the various Government Departments concerned, either in themselves or through increased facilities at the Ontario Research Foundation or the Royal Ontario Museum of Zoology, might concern themselves with investigations which have to do with problems of administration. Both the Foundation and the Museum could, of course, undertake pure as well as ad hoc research, while the Ontario Federation of Commercial Fishermen and the Ontario Federation of Anglers and Hunters and the Ontario Tourist Trade Association could materially assist in the collection of data and in extension work at the "consumer" level. The allocation of responsibility is, however, of minor importance here. The main consideration is that the required machinery exists at every level.

The Requirements

While there are sufficient organizations to undertake an adequate programme of research, they are, in the cases of the universities and the Foundation at least, badly handicapped by limited and obsolete facilities, and by a shortage of personnel. To a large extent research on fisheries and wildlife has had to be relegated to a position of minor importance, to an uncertain and disjointed existence, with recurrent revivals when space, time, and money permitted. In such circumstances there can be little doubt that much of the value of the work accomplished was lost.

The immediate needs may be summarized as follows:—

(1) Provision of Personnel:
   (a) The establishment of scholarships with a view to encouraging post-graduate work in the field of fisheries and wildlife.
   (b) The institution of a policy of employment preference for scientifically trained personnel in the administration of these resources to offer further encouragement to students in these fields.

(c) The institution of a policy of employment preference for undergraduates in these fields in temporary summer appointments for purposes of administration.

(2) Extension of Facilities and Staff

(i) Queen's University—Further extension of the laboratory at Lake Opinicon.

Research personnel.

(ii) University of Western Ontario—Provision of a barge which may be used anywhere on Lake Erie.

Research personnel.

(iii) McMaster University—Additional facilities for investigations re Dundas Marshes and Lake Ontario.

Research personnel.

(iv) University of Toronto—Temporary or permanent laboratory with space far beyond what exists at present.

Research personnel.

(v) Departments—Additional facilities and personnel in the Provincial Parks and River Development Areas and extension of projects contemplated.

(vi) Ontario Fisheries Research Laboratory.

Research personnel.

(vii) Ontario Research Foundation—Addition in the field of Parasitology.

(viii) Royal Ontario Museum of Zoology.
Additional staff.

(ix) Ecological Centre.

ROYAL ONTARIO MUSEUM OF ZOOLOGY

At its meeting in Toronto on November 9th, 1946, the Advisory Committee on Fisheries and Wildlife gave consideration to the place of the Royal Ontario Museum of Zoology in an integrated programme of fisheries and wildlife research in Ontario.

The Committee wish to emphasize that the Museum has an essential place in fisheries and wildlife research and that if it is not enabled to fulfil its function adequately, the whole programme will be weakened.

The Research Fields of Zoology Belonging to Museums

TAXONOMY or classification including identification, which is basic to every other branch of Zoology, is the special responsibility of museums. Unless the investigator has his animals properly identified, he may be led astray in his conclusions and lead others astray so that confusion rather than enlightenment is the result of his work.

Every properly organized museum has specialists in the identification and classification of mammals, birds, reptiles, amphibians, fishes, insects, and every other animal group, including parasites which belong to several groups.

Museum house collections of such animals which are as necessary for reference in identification and in taxonomic research as books are to a library.

For the identification of bones and other parts of animals found in the stomachs or droppings of animals whose food habits need identification, museums prepare and preserve collections of the skeletal and other parts of animals.

The care of its scientific collections is a permanent responsibility of museums.

DISTRIBUTION studies are of economic as well as of theoretical importance. Knowledge of the geographical and ecological distribution of an animal is valuable in indicating the conditions (a) necessary to be maintained for its success in its original habitat (b) responsible for its disappearance from situations in which it originally thrived and (c) under which it might succeed if transplanted.

The Museum's Educational Responsibilities in fisheries and wildlife are to the University, the schools, and the general public.

Students in training for positions in fisheries and wildlife need to know the mammals, birds, reptiles, amphibians, fishes, insects, molluscs, parasites, etc.

A constant flood of inquiries about animals comes to the Museum by letter, telephone and personal call from teachers, sportsmen, naturalists, authors, newspaper writers, authors, radio broadcasters and ordinary citizens.

The Museum's Service to the Department of Lands and Forests

The Department of Lands and Forests depends on the Museum for service for which it would have to provide staff and collections of its own if the Museum were not available.

The Needs of the Museum of Zoology

The Royal Ontario Museum of Zoology is not adequately staffed to meet its obligations as a Provincial Museum. It has curators in only two divisions,

namely birds and insects. It has no one in charge of such important divisions as mammals and fishes. It has recently lost its taxidermist and two other members of its staff because of inadequate salaries, which are in some cases from $500 to $1200 too low. It has very meagre funds for field work, purchase of specimens, publication, etc. Funds for all non-salary purposes are less than half what they were before the war and even then they were inadequate.

If the Royal Ontario Museum of Zoology is to provide the service in connection with research, administration and education in fisheries and wildlife, it must be given much more adequate support than now seems likely through ordinary channels. Even if funds were available it would be impossible to staff the Museum adequately at once. Personnel for the work to be done in a museum must be specially trained. Without reasonable prospects of a position being available, students will not undertake the necessary training. To serve the University, the Department of lands and Forests and the public in the matter of fisheries and wildlife research and education, the Museum of Zoology needs:—

Curator of Mammals.
Curator of Fishes.
Curator of Parasites.
Curator of Invertebrates other than insects (resigned and cannot be replaced on former salary).
Additional Entomologist (for forest insects among others).
Taxidermist (resigned and cannot be replaced on former salary).
Artist Assistant to assist in preparation of illustrations for fisheries and wildlife publications.
Wildlife Food Habits Research personnel.
General Attendant for cleaning inside gallery cases, cleaning laboratories, packing and unpacking, acting as supply clerk and messenger. All these must now be done by higher paid personnel.
Additional clerical and cataloguing assistance for above.
Publication Fund for popular and scientific publications.
Increased Appropriation for storage and gallery cases ($650.00 at present), specimens and collecting ($200.00 at present), library ($100.00 at present), field work ($500.00 at present).

It is suggested that a five-year programme of gradual expansion of the Museum of Zoology staff and work be undertaken looking to the realization of the expansion outlined above. To accomplish this, it is estimated that the following increases in appropriations would be necessary.

1947-48	$17,850 over 1946-47
1948-49	13,000 over 1947-48
1949-50	10,000 over 1948-49
1950-51	10,000 over 1949-50
1951-52	8,000 over 1950-51

Details of the increased appropriations suggested for 1947-1948 are as follows:—

Personnel:		
Salary Increases of Present Staff	$2,200.00	
Curator of Fishes (graduate student in training)	1,500.00	
Curator of Parasites (student in training)	1,200.00	
Artist Assistant (part time)	750.00	
Wildlife Food Habits Research Personnel	2,500.00	
General Attendant	1,200.00	
Additional Clerical Assistance	2,500.0	
		$11,850.00
Less Salaries of Taxidermist and Malacologist Resigned, not to be replaced at once		4,200.00
Total		$ 7,650.00
Field Work, Maintenance, etc.:		
Field Work Fund Increase		$ 2,000.00
Publication Fund		1,000.00
Cases, Specimens, Library and Miscellaneous Operating Increase		7,200.00
Total		$10,200.00

It is suggested that the Ontario Research Commission consider financing the following projects which are included under various items above, such as curator of parasites, wildlife food habits research, additional clerical assistance (part), field work, cases (part):—

Natural History Survey of Cape Henrietta Maria, Hudson Bay	$1,500.00
Wildlife Food Habits Research	3,500.00
Reference Collection of Animal Parasites	2,000.00
Compiling Records of Populations of Ontario Animals	500.00
	$7,500.00

This would leave $10,350.00 additional to the present Museum of Zoology appropriation to be financed through regular Museum appropriations (Department of Education).

Details of each of the above four projects suggested for financing through the Ontario Research Commission are attached.

Natural History of Cape Henrietta Maria

Previous to 1938, very little had been added to our knowledge of the natural history of the northern half of Ontario, beyond what we owed to Graham, Martin and Hutchins, Governors of Hudson's Bay Company posts on Hudson's Bay, who between 1768 and 1782 sent specimens and records from that area to England.

Beginning in 1907, the Carnegie Museum of Pittsburgh has sent 21 expeditions to the area east of Hudson's Bay.

In 1938 the Royal Ontario Museum of Zoology was given a grant of $5,000 from the Reuben Wells Leonard Fund to enable it to carry out natural history surveys in the District of Patricia. Under this grant the following surveys were carried out:

1938 Favourable Lake area near the Manitoba boundary.

1939 Lake Attawapiskat.

1940 Fort Severn on Hudson Bay.

1942 Fort Albany on James Bay.

In 1942 an attempt was made to visit the Cape Henrietta Maria area but owing to an accident to the Hudson's Bay Company boat, which was to have taken our party there, it was not possible to reach it

An indication that this area has interesting and important wildlife problems is afforded by the fact that the Arctic Institute of North America has awarded a fellowship to Harold C. Hanson of the Illinois State Natural History Survey for wildlife research on the west coast of James Bay.

Surely Ontario can afford to enable its Provincial Museum to investigate the fauna of our own areas.

Estimated Cost of this Survey	$1,500.00

Wildlife Food Habits Research

Knowledge of the food habits of fish and wildlife is basic to any programme of management.

There is immediate need of means for determining the food of moose as part of the Museum's moose research being financed by the Carling Conservation Club.

The Museum has a large collection of stomachs, scats and pellets whose examination would throw light on the relation of birds to forest insects and on the interfood relationships of mammals.

Need for the services of a wildlife food habits research laboratory will increase as studies on the life history and ecology of animals increase.

The Museum is the natural home of such a laboratory since it has collections of the mammals, birds, reptiles, amphibians, fish, insects, etc., of the Province.

Such a laboratory would need a microscopist, skilled in the identification of finely ground plant and animal material.

Estimated Cost:

Microscopist	$2,500.00
Equipment and Storage Cases	1,000.00
	$3,500.0

Reference Collection of Animal Parasites

Study of the parasites of wild and domestic animals has heretofore been very inadequate in Ontario.

In connection with various fish and wildlife studies (ciscoes, burbot, lake trout, maskinonge, ruffed grouse, pheasant, mice, deer, moose, etc., etc.), parasites belonging to many groups are found. At present there is no organized means of preserving specimens of these parasites except in the case of the few kinds receiving special study. In the future as arrangements are made for the study of more and more of these parasites a collection, not only of named specimens but of material that has not yet been studied, will be of very considerable value.

As the preservation of material of this kind is a recognized museum function, it is suggested that the collection of animal parasites be initiated by granting a research scholarship to a student to begin a taxonomic study of some group of parasites and to build up and care for a general collection.

Estimated Cost:

Graduate Student	$1,200.00
Field Expenses	300.00
Equipment	500.00
	$2,000.00

Compiling Record of Populations of Ontario Animals

The need for this item was outlined in the first list of projects presented to the Commission.

If the proposed Ecological Centre will take over this work, the Museum will drop this request.

Previous to the present development of interest in wildlife research, when practically nothing was being done in this field in Ontario, the Museum initiated and carried through this project for ten years. This continuous record will be of value in future studies of animal populations and should be continued by the Museum until some other organization will take it over. It has interfered

RECOMMENDED PROJECTS — FISHERIES AND WILDLIFE RESEARCH — 1947-48

QUEEN'S UNIVERSITY			
Services of full time limnologist		2,000.00	2,000.00
Construction of Research Laboratory for investigations in fisheries, entomology and bacteriology	3,800.00		3,800.00
Equipment for fisheries work, seines, nets, ekman dredge	400.00		400.00
One 15′ skiff	160.00		160.00
Salaries for 2 undergraduate men (3yr.) as research assistants at $100 per mth. for 4 mths.		800.00	800.00
Publication of reports and scientific articles		200.00	200.00
Board for 2 research assistants—4 mths. at $30 per mth.		240.00	240.00
	$4,360.00	$3,240.00	$7,600.00
UNIVERSITY OF WESTERN ONTARIO			
Study of Ecological Factors of Lake Erie most likely to have influence on fish population	9,273.00		9,273.00
Equipment		1,400.00	1,400.00
Maintenance		8,320.00	8,320.00
Salaries		2,184.00	
Living Expenses		1,400.00	
Salary for General Utility Man (to run boat 8 mths. at $175)			
	$9,273.00	$13,304.00	$22,577.00
ONTARIO RESEARCH FOUNDATION			
Parasitology	$2,000.00	$20,000.00	$22,000.00
TOTAL FOR FISHERIES AND WILDLIFE RESEARCH	$23,733.00	$66,099.00	$89,832.00

RECOMMENDED PROJECTS — FISHERIES AND WILDLIFE RESEARCH 1947-48

Title	Contributing Agencies	Capital	Operating	Total
UNIVERSITY OF TORONTO				
Penetration of Light into Water	Ont. Fisheries Research Lab., Dept. of Lands and Forests (Professor R. R. Langford)		650.00	650.00
Movement of Lake Trout in Relation to Temperature	University of Toronto, Dept. of Lands and Forests (Prof. F. E. J. Fry)		1,000 00	1,000.00
Bibliographic Research	Professor's Fry, Langford and Ide)		2,500.00	2,500.00
Organization of Ontario Fisheries Research Laboratory Library			1,200.00	1,200.00
Supply and Fate of Chemical Nutrients in Lakes and the Chemical Analyses of Organisms	Ont. Fisheries Research Lab., Dept of Lands and Forests (Fry and Langford)		1,175.00	1,175.00
Calorific Requirements of Lake Trout	University of Toronto and Dept of Lands and Forests		1,000.00	1,000.00
Relation of Dissolved Minerals to the rate of Growth and Reproduction of Algae	Ontario Fisheries Research Lab., Dept. of Lands and Forests	1,000.00	1,050.00	2,050.00
Lethal Limits of Temperature in Stream Insects with Special Reference to their Thermal History	Ontario Fisheries Research Lab., (Ide and Fry)		1,100.00	1,100.00
Bionomics of the Lake Trout Population of Lake Louisa, Algonquin Park	Ont. Fisheries Research Lab., Dept. of Lands and Forests		1,400.00	1,400.00
		$1,000.00	$12,575.00	$13,575.00
ROYAL ONTARIO MUSEUM				
Natural History Survey of Cape Henrietta Maria, Hudson Bay			1,500.00	1,500 00
Wildlife Food Habits Research		1,000.00	2,500.00	3,500.00
Reference collection of animal parasites			2,000 00	2,000.00
Compiling Records of Populations of Ontario Animals			500.00	500.00
		$1,000.00	$6,500.00	$7,500.00
	(In addition the Royal Ontario Museum are requesting $10,350 additional appropriation from regular sources)			
McMASTER UNIVERSITY				
Ecology of the Muskrat	McMaster, Dept. of Lands and Forests, Hamilton Harbour Commission, Royal Botanical Gardens (Mr L. Wragg)	500.00	2,630 00	3,130 00
Study of Physico-Chemical Conditions in the Bay and Marsh Waters	McMaster, Lands and Forests, Hamilton Harbour Commission, Hamilton Dept. of Health, Royal Botanical Gardens (R. E. M. Kay and E. Turner)	500 00	1,675.00	2,175 00
Collection and Identification of the Flora of the Dundas Marsh Region	McMaster, Lands and Forests, Hamilton Harbour Commission, Royal Botanical Gardens (W. W. Judd)		800.00	800.00
The Collection and Identification of Fish Species Indigenous to the Marsh Area	McMaster, Lands and Forests, Hamilton Harbour Commission, Hamilton Dept. of Health, Royal Botanical Gardens (A. E. Warren)	300.00	375.00	675.00
A Study of the Capacity for Survival in Local Waters of an Introduced Variety of the Minnow Gambusia	McMaster, Hamilton Dept. of Health, Royal Botanical Gardens (A E. Warren)	50 00	650.00	700.00
Life History of the Carp	McMaster (A. E. Warren)		735.00	735.00
Study of Aquatic Insects	McMaster, Royal Botanical Gardens, Hamilton Dept. of Health (W. W. Judd)	350.00	825.00	1,175.00
Mammalian Fauna of the Royal Botanical Gardens and Surrounding Areas	McMaster, Royal Botanical Gardens (A. E. Warren)	300.00	850.00	1,150.00
Station Wagon		1,600.00		1,600.00
Boathouse		2,500.00		2,500.00
Office, Secretarial, etc.			1,940.00	1,940.00
		$6,100.00	$10,480.00	$16,580.00
QUEEN'S UNIVERSITY				
Services of full time limnologist			2,000.00	2,000 00
Construction of Research Laboratory for investigations in fisheries, entomology and bacteriology		3,800.00		3,800.00
Equipment for fisheries work, seines, nets, ekman dredge		400.00		400.00
One 15' skiff		160.00		160.00
Salaries for 2 undergraduate men (3yr.) as research assistants at $100 per mth for 4 mths.			800.00	800.00
Publication of reports and scientific articles			200.00	200.00
Board for 2 research assistants—4 mths. at $30 per mth.			240.00	240.00
		$4,360.00	$3,240 00	$7,600.00
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		$9,273.00	$13,304.00	$22,577.00
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	TOTAL FOR FISHERIES AND WILDLIFE RESEARCH	$23,733.00	$66,099.00	$89,832.00

with other work which more properly belongs to the Museum. The carrying on of such projects, rather than its more legitimate work, may be the reason the Museum has not been supported more adequately.

Estimated Cost $500.00

ECOLOGICAL CENTRE

The Fisheries and Wildlife Advisory Committee has recommended the development of a fully equipped and fully staffed Ecological Centre to form an integrated part of the whole Fisheries and Wildlife Research Programme within the Province. Since such a centre cannot rise fully developed from thin air, it is recommended that as a beginning an attempt be made to obtain about 4,000 square feet of space in reasonably close proximity to Queen's Park. (10 minutes walk.) The space should have ordinary heating, lighting and plumbing services. If such space could be made available the following groups of workers could be housed immediately.

A. **Six** graduate students in Zoology (working under the direction of the Department of Zoology).

B. **Ten** graduate students in Forest Entomology (working under the direction of the Department of Forest Entomology).

C. **One** librarian with assistant working on animal population data under the direction of the Royal Ontario Museum of Zoology and the Fisheries and Wildlife Division of the Department of Lands and Forests.

D. **One or two** graduate students working on Wildlife problems under the direction of the Department of Zoology and the Fisheries and Wildlife Division of the Department of Lands and Forests.

E. **Visitors**—Space for the accommodation of two graduate students working in the Province who may wish for a period to bring their problem to the centre for study.

COMMITTEE ON FORESTRY RESEARCH

Meetings—

Informal.....Feb. 20th, 1946—Library, Ontario Research Foundation

Advisory
Committee.....Sept. 25th, 1946—Committee Room No. 2, Parliament
" .....Nov. 25th, 1946— Bldgs.

Committee—

Professor. C. E. Atwood	University of Toronto
Mr. A. B. Baird	Dominion Parasite Laboratory, Belleville
Dr. W. Boyd Campbell	Pulp and Paper Industries Association
Dean G. G. Cosens	University of Toronto
Mr. C. B. Davis	Abitibi Pulp & Paper Company
Mr. W. A. Delahay	Ontario Forest Industries Association
Dr. G. H. Duff	University of Toronto
Professor R. O. Earl	Queen's University
Mr. D. A. Gillies	Gillies Bros. & Co. Ltd.
Mr. O. Holden	Ontario Hydro-Electric
Mr. R. Johnston	Lands and Forests
Major-General H. Kennedy	Ontario Commission on Forestry
Mr. W. LeClair	Canadian Lumbermen's Association
Dr. A. Ledingham	National Research Council
Mr. D. A. Macdonald	Assistant Dominion Forester
Mr. F. MacDougall	Lands and Forests
Dr. H. B. Marshall	Ontario Research Foundation
Mr. T. A. McElhanney	Forest Products Laboratory
Professor R. McLaughlin	University of Toronto
Mr. K. O. Roos	J. R. Booth Lumber Limited
Professor J. W. B. Sisam	Univerity of Toronto
Mr. S. J. Staniforth	Staniforth Lumber Co.
Mr. G. H. Tomlinson II	Howard Smith Paper Company
Mr. A. H. Richardson	Planning and Development

THE PRODUCTION OF WOOD IN ONTARIO

Prepared by a Sub-Committee of the Major Groups in the Province of Ontario Interested in Forestry

INTRODUCTION

In assessing the importance of any problem, it is helpful to appreciate its size, and its significance to those affected by its solution. On this basis, there should be no question of the size and importance of the forest problem to the Ontario community.

Excluding old Ontario, something on the order of 95% of the Province's land area—about 175 million acres—is occupied by forest stands of some type or condition; it is doubtful if present economic conditions or any economic condition that can be foreseen in the immediate future will materially alter this situation.

As to the importance of the Forest to the Ontario community it is probable that no single individual in the Province does not depend to some extent, or in some form, upon the wood produced from Ontario's forests.

Anyone who has given the matter thought must also realize that in addition to its direct contributions in the form of diversified wood products, the indirect effects of the forest as a source of water for power and fisheries, a shelter for game, an attraction for tourists and a general protection against the drying and erosion of agricultural soils, play a very great and beneficial part in the Provincial economy.

A brief statement here as to the value of the forest to Ontario, and its relation to other natural resources should give point to what has been stated above:

1934

	Agriculture	Forest Industries	Mining Industries
Gross Value of Products	$586,467,000	$372,000,000	$232,848,959
Employees	317,416[2]	69,000	33,516
Wages	$383,711,000[3]	$104,000,000	$67,732,244
Area Occupied(sq. miles)	7,958,100	118,000,000*	

1—Area south of the Albany-English River line.
2—Hired farm workers only.
3—Cash income from farm products.
Remarks—Value of Tourist Traffic estimated at $89,000,000.

Unfortunately, many people, and particularly those living in old or Southern Ontario—which differs greatly from the remaining 95% of the Province in climate, soil and topography—do not realize these conditions and problems. Until this large group is aware of this situation, the diversion of adequate funds for forest research will be uncertain and liable to serious interruptions.

GENERAL RECOMMENDATIONS

1. Educational Requirements

At the present time there are few engaged in forest research who have post-graduate degrees in forestry or allied subjects. There has been little encourage-

ment for promising students to do postgraduate work in forestry and there are few facilities for such work in Canada. There are apparently two crying needs at present:

1. Encouragement of promising students to do postgraduate work in forestry and allied subjects in Canada by fellowships by employment during holidays and by prospects of remunerative employment after their university work is completed.

2. Comparative standing for those in research who have no postgraduate degrees with those who have. Some have advanced the rule of thumb that ten years of research experience should equal a doctor's degree.

It will be some time before the field is crowded with postgraduate students and some system of classing the workers is essential.

2. Co-operative Groups and Institutions

(1) Universities

The Universities can aid in this programme by increasing facilities for postgraduate studies and by facilitating research by their staff, The staff should be encouraged to seek outside employment on investigative programmes during the summer holidays.

(2) Ontario Research Foundation

The Ontario Research Foundation is in a good position to carry on a programme of research into fundamental problems of chemistry and biology and to render competent aid when necessary to organizations unable to build up a staff to handle all problems. The National Research Council is also in a position to render such assistance.

(3) The Dominion Forest Service

This organization by history, location and experience is ideally placed to render a valuable service in research, both fundamental and applied. There should be no difficulty about so-called overlapping with other organizations because the field is so large and untouched, that even if all the research workers now available were concentrated on one phase of forestry work, there would be no duplication of work or waste effort. The field of the Dominion should probably be predominantly fundamental research and that of the Province mainly applied research.

3. Co-ordinating Group

It is recommended that a group made up of representatives from (a) Universities, (b) Dominion Government, (c) Industry, and (d) the Province, should be set up to:

(i) formulate a completely integrated programme of forest research;

(ii) provide a common meeting ground for the discussion of forest research problems;

(iii) act as a clearing house for all research information published and unpublished, relative to any part of Ontario's forest research problem;

(iv) suggest general lines of research to its member organizations.

SPECIFIC RECOMMENDATIONS

1. Expansion of present research programme of the Department of Lands and Forests, which includes the following major sub-divisions:

   (a) Surveys—Forest and Soil Inventories (see Appendix A).

   (b) Biological Investigations (see Appendix B).

   (c) Forest Economic Investigations (see Appendix C).

   (d) Protection and Mechanical-Electrical Investigations (see Appendix D).

   Appropriations for the above programme for 1946 provided funds to utilize nearly all of the competent technical staff available. This amount should, however, be increased as technicians now in trainng become available.

2. Additional forest research stations and demonstration forests should be established to study local forest problems. At least one station should be allotted to each general forest region. These are:

   (a) The Western jack pine—spruce-poplar forest.

   (b) The Clay Belt black spruce-poplar forest.

   (c) The white pine-red pine-tolerant hardwood-—Huron-Ottawa Forest.

3. Forest Research is of little value unless its findings can be applied through Forest Management. Neither management nor research can function properly in Ontario's forest area until an adequate transportation system has been developed.

4. An inventory of forest resources is as necessary for Forest Management as it is to any other business. Such an inventory must be obtained and, once secured, should be periodically revised to maintain necessary accuracy.

CONCLUSIONS

1. A developing forest research programme will require some general organizing agency which will represent:

   (a) The wood production organizations (governments).

   (b) The wood harvesting and fabricating organizations (industry).

2. Educational services are urgently required to:

   (a) Provide research technicians.

   (b) Provide a body of informed public opinion which will guarantee a continuation of adequate support for forest research under a democratic form of government.

3. The whole problem of forest research has been inadequately financed due to a lack of appreciation of the importance of the general forest problem; forest research cannot now be efficiently expanded as rapidly as is desirable because of lack of trained and competent workers.

   As indicated by Appendix "E" which summarizes replies from twelve representative foresters throughout the Province, very little research is at present underway. Recommendations for financial support to cover specific programmes or problems is, therefore, difficult.

In general, however, it is recommended that the Research Advisory Committee (a) secure funds to inaugurate and support fundamental forest research to cover both wood production and utilization in existing research organizations and universities; specific projects to be designated by the co-ordinating group previously recommended: and (b) that, the Commission support the Department of Lands and Forests in its research programme so that applied research projects already undertaken by the Department may be enlarged and in addition co-operative applied research may be undertaken with industry on a larger scale.

Departmental appropriations for this work in 1946 approximate $400,000.00. An additional $150,000.00—$75,000.00 ordinary and $75,000.00 capital—could be usefully invested in 1947. It is considered that in the present state of our forest problem expenditures for fundamental research and for applied research should be approximately equal.

APPENDICES

Appendix A

Soil survey Cochrane and Parry Sound districts. This is a continuation of the programme of 1944 which started in the Port Arthur region to separate forest and agricultural soils. The work was carried to the Cochrane district in 1945 and is to be continued there in 1946, with an extension to the Parry Sound region. A soil laboratory for chemical and physical analysis has been set up near Maple, Ontario.

Forest Inventory Survey: This survey will provide the Department with (a) a complete photographic base survey of Ontario, (b) a forest inventory survey giving quantities of wood and forest conditions.

Appendix B

Natural regeneration surveys in Port Arthur, Kapuskasing and North Bay districts. To be continued and extended to Kenora district. Covered to the present time about 230,000 acres—13 students employed on this work in 1946.

Experimental slash disposal by chemical means (Pyrogel). This may enable the burning of damp slash in relatively safe weather and simplify the problem of live burning of slash.

Slash disposal by lopping or burning with or without brush destruction by chemical means, 2-4-D, and followed by artificial or natural seeding, also planting. Port Arthur and Kenora districts 300 acres done in 1945 and continued in 1946 on a smaller scale.

Large scale low cost collection of spruce and jack pine seeds without cone picking, seed to be used in experimental restocking of areas now accessible but without conifer. Some of seed to be pelleted and results compared with use of uncoated material, 1946 project.

Biological survey of fish and game resources, Algonquin and Quetico Parks. This is conducted in co-operation with the University and the Museum and is part of a long term project. A fish study laboratory is to be added to the Experimental Station at Maple, Ontario.

Appendix C

Study of stumpage prices or bids for the right to cut on Crown lands. Local variations appear excessive and are to be investigated with the object of protecting the bidder and the Crown.

Appendix D

DDT spraying for control of spruce budworm in the Port Arthur region with biological check on results. This is a continuation of the programme in 1945 when 100 square miles were sprayed.

Sulphur fume survey in the Sudbury district now in its third year is being continued to determine the existence and the amount of smelter fume damage to Crown forest property.

Mechanical equipment, pump and hose and communication equipment are being tested in the newly completed mechanical building at the Maple Station.

In addition to the above it is proposed to set up a forest research station in the Clay Belt and in the Port Arthur region where all forest problems of these areas can be studied theoretically and by actual practice in the field.

Appendix D-1

Extract from Article on Spruce Budworm by Dr. Carl Atwood
Basic Information Required in Connection with the Spruce Budworm Problem

(In the following list some of the more obvious gaps in the fundamental knowledge necessary for solution of the spruce budworm problem are indicated together with the organizations which might logically be expected to help fill these gaps.)

1. Forest inventory, including young growth, advance reproduction, etc. Kept up to date by frequent surveys.
2. Study of factors governing regeneration of balsam and spruce on various sites and soil types.
3. Study of physiology of balsam in various forest types, especially in two contrasting areas which produce "good" and "poor" balsam.
4. Studies on flotation of balsam in comparison with that of spruce; comparison of "eastern" and "western" forms.
5. Genetic study of balsam with special reference to the presence of budworm-resistant races.
6. Study factors which influence production of staminate flowers and also seed in balsam.
7. Studies on forest succession in outbreak and non-outbreak areas. (Studies of this type appear to belong logically to the field of activity of either the Dominion or Provincial Forest Services or to botanical departments of Universities.)
8. Studies on composition of forests in relation to budworm outbreaks.
9. Studies on methods of dispersal of the various stages of the budworm including influence of weather.

10. Studies on fertility and fecundity of budworm with special reference to type of food which larvae eat.
11. Studies on sampling methods for budworm populations and also for foliage of infested trees.
12. Determination of upper and lower lethal, preferred and optimum temperature for all stages of budworm.
13. Investigation of life histories and relation to host of all budworm parasites. Also temperature relations of chief parasites as in 12.
14. Detection, classification and study of any existing budworm diseases. (These and similar projects would logically be carried out by the Division of Entomology and the Forest Entomology section of the Department of Zoology at the University.)
15. Methods of distribution and effectiveness of poisons against spruce budworm. (This is now set up as a joint project of the Department of Lands and Forests, Toronto, and the Division of Entomology, Department of Agriculture, Ottawa.)
16. Effect on game and fish of changes produced in the forest as a result of budworm attack.
17. Influence of birds and small mammals on budworm populations at various stages of their life cycle. (Could be handled by Department of Zoology in co-operation with Departments of Game and Fisheries and of Lands and Forests (Toronto) and Department of Agriculture (Ottawa).

Appendix E

The questionnaire used to obtain the opinion of professional foresters in both industry and Government service was placed before twelve selected individuals, six in Government service and six in industry. Ten replies were received, five from each group,

In general, the questionnaire asked for information on two points (1) a record of research to provide a statement of work completed and under way, planned and desired and (2) a statement of the general class of problems considered most urgent.

SUMMARY OF STATUS OF RESEARCH

	Agencies Polled	Replied	Research Completed	Research in Hand	Research Desired
Industry.....	6	5	1	1	5
Government...	6	5	2	1	5

PRIORITY OF RESEARCH PROJECTS

	Regeneration	Survey	Protection	Silviculture	Mechanical Equipment
Industry.....	First 3	First 1	First 2	..	..
	Second 1	Second 1	..	Second 1	..
Government...	First 2	..	First 1	..	..
	Second 2	..	Second 2	..	..

RESEARCH ON THE UTILIZATION OF WOOD IN ONTARIO

Prepared by a Sub-committee of the Major Groups in the Province of Ontario Interested in the Forest Industries

A. The Forest Industries and Research

The importance and value of expenditures on research in any industry might be said to be in direct proportion to the value, both actual and potential, of that industry to the area concerned. The following data, compiled by the Dominion Bureau of Statistics, indicates the present importance of the Forest Industries to the economic life of the Province of Ontario:

	1937		1943	
	Wood and Paper	% of Total	Wood and Paper	% of Total
Total Number of Establishments	2,618	27	2,932	28
Capital Invested, $ millions	338	20	378	13
Employees, thousands	56	17	69	12
Salaries and Wages, $ millions	68	18	104	11
Cost of Materials, $ millions	99	10	164	7
Net Value of Products, $ millions	123	15	195	11
Gross Value of Products, $ millions	232	12	372	9

The purpose of research on utilization in the wood-using industries is two-fold:

1. To asertain the manner in which the forest resources of the Province should be exploited so as to provide the greatest use-value in tems of value of production, employment of labour, etc., and to find the most suitable methods of using species of trees which now have little or no apparent value. The latter objective is really a form, and a most important one, of the conservation of our forest resources.

2. To develop techniques of manufacture and methods of eliminating waste so that the cost of the finished products of the industry will be such as to allow the industry to compete in the domestic and export markets. Ability to compete in export markets is the life-blood of the wood-using industries in Ontario and in Canada.

   Many of the operations in converting wood into lumber, plywood, pulp, paper, rayon, plastics, chemical products and engineering materials are highly technical and scientific. This means that research must cover many fields of scientific endeavour such as chemistry, physics, biology, pathology, forestry, engineering, etc. This broad field cannot be covered by one or two agencies but requires the co-operative effort of many organizations.

   Important technical advances have been made in the use of wood during the past twenty-five years and the recent war has hastened these developments. These advances, however, only result in emphasizing the unlimited possibilities in the use of wood as a raw material. Despite the considerable fund of knowledge already acquired, too little is yet known about this highly complex and variable material called wood. More and more intensive research is required.

In using the term "research" it is customary to consider two types or levels—firstly, basic research and secondly, industrial research.

The object of basic research is the searching out and the organizing of the fundamental facts concerning the materials used and the processes employed in using them, without direct reference to the commercial application of the results. Such work is usually done by university laboratories or by special institutions such as the Pulp and Paper Research Institute of Canada.

The object of industrial research is concerned with the finding and the developing of new processes of manufacture and of new products. Such work is usually done by government organizations such as the Forest Products Laboratory of the Dominion Forest Service, by specially endowed institutions such as the Ontario Research Foundation, by commercial laboratories and by industry itself.

In using these definitions, however, it must be kept in mind that no clear-cut dividing line can ever be drawn between those two levels of research. The distinction is mainly useful in determining the type of organization most suitable for conducting work in the various fields that are to be covered.

B. Research Now Being Done

A tremendous amount of research on the utilization of wood is now being carried on by many agencies in Canada, in the United Kingdom, in a number of European countries, and particularly in the United States. In fact it might almost appear that there was a sufficiency of organizations already working on these problems Such a conclusion, however, may not be warranted. In the first place, the field is so broad and the problems so diverse that many minds and many methods of attack will be required to produce the desired results. In the second place, many of these agencies are hampered by lack of sufficient staff and facilities to properly carry out their work.

In this connection it does appear that, while there is a considerable amount of research being carried on, there is a definite lack of a control organization, or organizations, where all relative information concerning these problems can be gathered together and made available to those interested. This situation may, and undoubtedly does, result in much duplication of effort on the part of research agencies on the one hand and the failure of industry to avail itself of the knowledge already gained on the other. The results achieved by basic scientific research are fairly generally distributed through various channels but the same cannot be said for the results of industrial research.

The following gives a brief summary of the major agencies now engaged on wood utilization research in Canada:

The Forest Products Laboratories of Canada

This organization is operated and financed entirely by the Dominion Government through the Dominion Forest Service. The main laboratory is in Ottawa and a branch is maintained in British Columbia in association with the University of British Columbia. The work of the Forest ProductsLaboratories is concerned with problems relating to all of the Provinces of the Dominion.

The Laboratories are primarily concerned with investigations having to do with improvement of products or methods of manufacture, new uses for raw material and curtailment of waste in industry. This is largely industrial research although a certain amount of basic research must necessarily be done where the required data is lacking.

Investigations undertaken by the Laboratories are of several kinds. There are those of general interest which are initiated by the staff of the Laboratories or they may be suggested by industry. Secondly, there are those of more limited interest but which will be undertaken if the possible results would seem to justify the effort. Thirdly, there are those requested by a specific company or individual. In such cases a charge is made but little of this type of work is done. Finally, there is the co-operative investigation by the Laboratories and a wood-using industry, in which each share a portion of both the work and the expenses. Much valuable work of this character has been accomplished.

The type of problem investigated by the Laboratories includes Timber Mechanics, Containers, Plywoods and Veneers, Physics, Preservatives, Lumber Seasoning, Timber Pathology, Wood Paints, Wood Hydrolysis, Wood Plastics, Wood Distillation, Chemical Extracts, Wood Technology, Logging and Sawmilling, Secondary Industries, Economic Studies and Pulp and Paper. For a more complete list see IX. 3. a. (Ref. The Forest Products Laboratories Programme of Work, 1946-47.)

The Forest Products Laboratories are also in active co-operation with the Pulp and Paper Research Institute concerning matters relating to pulp and paper problems.

The Pulp and Paper Research Institute of Canada

This Institute is a co-operative effort on the part of the Dominion Government, McGill University and the Canadian Pulp and Paper Association, all three parties participating financially. The work of the Institute is under the control of a Joint Administrative Committee consisting of representatives of the three parties concerned. A laboratory is maintained in Montreal and many investigations are carried out at McGill University and at the Forest Products Laboratory in Ottawa.

The work of the Institute is primarily that of basic research on problems relating to pulp and paper, the application of the results obtained being left to industry itself. A certain amount of testing is done on behalf of individual companies for which a fee is charged. The Institute maintains a library and information service which is made available to industry.

Problems now under study by the Institute include Investigation of the Mechanical Pulping Process, Improvement of Testing Methods, Investigation of the Beating Process, Determination of Pulp Surface, Printing Studies and Analysis of Sulphite Waste Liquor. (Ref. The Forest Products Laboratories, Programme of Work 1946-47).

National Research Council

The National Research Council of the Dominion Government has not directly concerned itself with research on wood utilization or on forestry. Much of its work, however, is necessarily closely related to these fields and the fairly extensive facilities of its various divisions and laboratories can be of great assist-

ance to the wood-using industries. The Council also maintains an extensive library of basic scientific data which can be made available to all research workers.

Included among the problems relating to wood utilization on which the laboratories of the Council can give direct assistance are Hygroscopicity of Materials, Investigation of Strength of Materials, Examination of Wood Fibres, Use of Wood in Aircraft Construction, Plastics and Plastic Bonding of Wood, Preservation and Surface Protection of Wood, Rotproofing of Cellulose Materials, Packaging Research, Utilization of Agricultural and Forest Wastes by Chemical Conversions and Industrial Fermentations.

Universities

(a) University of Toronto

The greater part of the research directly relating to wood utilization presently carried on in the University of Toronto is that being done by the Department of Chemical Engineering.

Such investigation includes:

(1) Study of the bonding of plywood with synthetic resins.

(2) Study of the recovery and use of lignin and other materials from sulphite waste liquor.

(3) Study of the possibility of obtaining new products from the distillation of wood.

(b) The other universities in Ontario are doing no direct basic research on wood utilization. This situation is mainly due to a lack of sufficient staff and facilities.

(c) It should be noted here that the universities would appear to be the logical organizations for the carrying on of basic, scientific research. Basic research, being the seeking after fundamental knowledge, requires a detached and long-range viewpoint unconcerned with immediate commercial results. The university laboratories are ideally suited for this purpose.

In the second place, the primary objective of the university is to educate. To do this properly requires not only adequate facilities and teaching staffs but also an atmosphere which encourages students to continue their studies after graduation and to become expert in their special fields of scientific endeavour. An active programme of research is essential to the attainment of this object. At the present time research work of every kind is greatly restricted owing to the lack of suitably trained men. The universities must provide the men required.

Owing to the fact that undergraduate teaching, graduate teaching and research are inextricably intermingled, these two functions can be discharged simultaneously if the conditions at the universities are suitable in this respect. This has been generally understood but the provision of these conditions has lagged behind the need. Physical facilities, while considerable, are not sufficient. Teaching staffs have been too few in number to allow such men to carry on research in addition to the heavy burden of administration and of regular teaching and laboratory work. Salaries paid to teaching staffs are generally inadequate. Finally, too little encouragement and financial assistance has been given to trained men to engage in post-graduate work although the provision of scholarships, fellowships and prizes by governments, industry and individuals has been of considerable help in this respect.

An excellent explanation of the place of universities in research has been given by D. L. Thomson, Dean of Graduate Studies and Professor of Biochemistry, McGill University, in an address presented to the Canadian Chemical Conference in Quebec on June 6th, 1945.

Industrial Laboratories

All pulp and paper companies maintain laboratories for the technical control of production but, in addition, a number of these companies are engaged in industrial research as well. There has been an increasing tendency on the part of the pulp and paper companies in recent years to extend their staffs and facilities for industrial research and this movement will undoubtedly be continued.

Other industries using wood or its derivatives as a raw material such as in plywood, rayon, plastics and various products in which cellulose is a base maintain, in varying degrees, laboratories for industrial research.

Owing to the manner in which the lumber industry is organized practically no research is carried on by individual companies. The lumber industry and the related wood-working industry are composed of relatively small units which are unable individually to afford the cost involved in research. For this reason the industry has relied to a large extent on the Forest Products Laboratories and to some extent on the users of its products.

Commercial Laboratories

There has apparently been no great development in this field in Canada. By commercial laboratories is meant a laboratory and technical service organized privately and maintained by the fees charged for work done.

The Ontario Research Foundation

This Foundation was originally founded through the co-operation and financial assistance of both industrial concerns and the Provincial Government. Its purpose is to provide research facilities to both industry and agriculture in Ontario. As a result of the original endowments, such services can be provided for fees which cover only the direct operating cost involved.

Any company or organization in Ontario may ask the Foundation to work on a research project on their behalf. If the project appears to have merit and if the necessary facilities are available, the work will be undertaken, with the applicant bearing the direct cost involved. In these cases, the results of this research become the property of such company or organizations. The Foundation does a certain amount of independent work that is exclusive of these definite arrangements with specific industries but lack of staff and funds has restricted this type of work.

It should be said that the Foundation is providing invaluable assistance to industry and agriculture in the Province. The further possible development of this organization is covered later in the section on Recommendations.

Foreign Agencies

A vast amount of research on wood utilization is carried out in many other countries including the United States, the United Kingdom, Sweden, Finland, Russia, Australia and New Zealand. It is well-known that Germany had made great strides in wood research prior to the war.

The United States has been particularly active in this field and the work of the Forest Products Laboratories of the United States Forest Service has been outstanding. In addition, this work is being carried on by other Federal and State organizations, by universities, by industrial associations, by private companies, by private institutions and by commercial laboratories. (Ref. "Forest Products Research Guide" by the American Forest Products Industries, December 1945.)

It is interesting to note here that, at a recent conference on State and Federal Forest Products Research, the groundwork was laid for a permanent organization of research scientists, technicians and wood-using industries. The purpose of this organization is to collect information on forest products research, to distribute this information among those interested, and to act generally as a clearing-house for all agencies and individuals working in this field.

C. Suggested Fields for Further Work or New Projects

It is difficult if not impossible to make definite suggestions with regard to the actual problems which should be studied. The field is so vast, the possibilities so great and the knowledge still to be gained so varied and extensive that it is only guesswork to predict what avenues will give the greatest results. It can safely be said, however, that all present endeavours along these lines must be encouraged, facilitated and extended.

This problem is particularly difficult in connection with basic research. Here results will largely be achieved by the research worker acting in accordance with his own ideas and hopes. These results may be valuable or worthless but they cannot be predicted. Too much direction or organization in this field is not recommended. The problem may be briefly stated by saying that more knowledge is required about the chemical and physical properties of the various species of wood.

In connection with industrial research the problem is somewhat clearer in that industry, which hopes to benefit by the results achieved, has some idea of what it wants. The methods to be followed in attacking the problem, however, may be unknown and the solution may come from unexpected sources.

It might be noted here, however, that developments during the recent war have shown that results can be achieved when research workers are given specific problems to solve. This has been evident in the great advances made in the packaging of materials, the construction of wooden containers, the use of wood in aircraft and boats, the construction of timber buildings, the use of cellulose in explosives and in many other lines.

The following are a few of the major problems which appear to require a solution:

Lumber

The utilization of the waste now produced in logging, milling and wood-working operations. This is all-important. It is estimated that well over 50% of the tree volume is wasted.

More engineering data on the use of timber in construction.

Better methods for seasoning lumber.

Chemical treatment of lumber with a view to improving its qualities with respect to hardness, strength, shrinkage, decay and fire resistance.

Plywood

Improvement of binding techniques.

Improvement in glues and adhesives.

The possibility of using lower grades of timber.

Chemical Products

The possibilities of the development of a chemical industry based on wood as a raw material should be further examined. Such products now include alcohol, yeast, lubricants, charcoal, producer gas and many other materials.

Pulp and Paper

The utilization of the waste liquor now produced in the pulping process.

The use of species of wood not now considered suitable for the manufacture of pulp.

The use in the manufacture of pulp of the waste remaining from sawmilling and wood-working operations.

The improvement and standardization of methods of testing the qualities of pulp and paper.

Further basic research on the characteristics of cellulose, lignin and the other component parts of wood.

For a more detailed list of research problems in the pulp and paper industry see IX. 3. 6 (The Forest Products Laboratory Programme of Work, 1946-47). (i) Regeneration Survey.

D. Recommendations

It is difficult to make specific recommendations covering such a broad field and it is particularly difficult to suggest the obligation that should be assumed by one province. This is primarily a nation-wide problem and yet each province is vitally interested through its ownership and control of the majority of the forest-producing lands. Furthermore, every province must assume some responsibility for the well-being of industry within its borders. It is a known fact that the Province of Ontario, and the other provinces as well, derives a considerably higher direct income from its forests than is spent on the administration, protection and improvement of these forests. Owing to the great importance of the forest industries to the welfare of the Province, greater expenditures could profitably be made on the forests and this should include expenditures on forest and wood utilization research.

In making the following recommendations it has been kept in mind that this is both a national and a provincial problem. It appears to be desirable that there should be some machinery for a greater co-ordination of effort and an exchange of information on a nation-wide basis but it has not been considered that an examination of such Dominion-Provincial relations was to be a part of this report. It is felt, however, that any steps that might be taken by the Province of Ontario to carry out these recommendations would in no way interfere with, and would satisfactorily fit in with, any steps that might be taken later on a broader basis.

It is therefore recommended:

1. That the Board of Governors of the provincial universities be requested to submit a report on their requirements for additional staff and facilities necessary for the proper carrying out of an adequate programme of basic research on the utilization of wood and that, on the receipt of such reports, steps be taken to provide the funds necessary for the carrying out of these programmes.

2. That a Director of the Ontario Research Foundation be requested to submit a report on the requirements for additional staff and facilities necessary to provide:

   (a) Expanded facilities in the Foundation so that a broader and more adequate service may be provided to industry in Ontario.

   (b) Sufficient facilities and staff so that the Foundation may carry out desirable research endeavours independent of those requested by specific industries.

   And that, on the receipt of such report, steps be taken to provide the necessary funds.

   And that the facilities offered by the Foundation be more widely advertised among the industries in the Province.

3. That steps be taken to encourage industrial associations and private companies in the Province to provide more funds for fellowships, scholarships and prizes for the purpose of encouraging and assisting students who desire to continue in graduate studies and research work.

4. That the Province of Ontario establish an "economics research" or "intelligence" organization having as its primary purpose the collection, organization, and distribution of all available knowledge concerning forestry and forest-products research. The information to be collected by this organization should not be confined to scientific data only but should include all information relating to the economics of the forest products industry. Such an organization could be invaluable as a source of information to industry and to research workers generally. There is a definite lack of such a source at the present time.

   Of equal importance is the fact that this organization would be in a position to advise the Government on all matters relating to research and it should be empowered to initiate such investigations as may seem desirable and to report the results to the proper authorities.

   It is conceivable that such an organization might be set up to cover the needs of all industries and of all research in the Province. In this event, it is strongly recommended that a separate division covering the forest industries alone be provided as this single field is of a size and importance to warrant such treatment.

   Finally, the direction of such an organization must be placed in extremely competent hands which will be capable of combining both the scientific and economic aspects of the problems that will be encountered.

THE GENERAL FIELD OF RESEARCH OF THE FOREST PRODUCTS LABORATORIES

The following is intended to indicate the types of research carried out in the Forest Products Laboratories. More detailed information is available in the 1946-47 Programme of Work of the Laboratories.

Types of Work

Timber Mechanics—Physical properties of different species; mechanical properties of large structural timbers; standards for use in grading structural timbers; timber fabrication for housing and heavy structures; structural assemblies; laminated constructions.

Containers—The design and testing of containers for shipment of export commodities (wood, fibreboard, plywood, paper, etc.); the setting up of standards of design and performance; collaboration with the Canadian packaging Committee; the Canadian Standards Association, Government Departments and industry.

Plywoods and Veneers—Technical problems in veneer and plywood manufacture; adhesives and adhesion problems; the operation of a pilot plywood plant for work on different species and processes; industrial applications of plywood; utilization of waste in veneer plants.

Physics—The application of physics to methods of testing and to procedures; the development of new techniques and new technical equipment; the application of infra-red and electronic heating to problems of drying, adhesion, and veneers and plywood moulding.

Wood Preservation—The preservative treatment of timber with toxic chemicals; new preservatives, their effect on fungi, insects and marine organisms; methods of application of preservatives (pressure or non-pressure); the operation of a pilot scale wood preservation plant; long-term durability tests of preservatives; service records of treated timber in structures; plant control and control instruments and equipment; the application of fire-retardant chemicals and paints; wood paints in the maintenance of wood structures.

Timber Pathology—The investigation of the organisms causing decay, staining and moulding of wood; the significance of such organisms in the service life and marketing of the timbers; methods of preventing the development of such organisms; the control of slime in pulp and paper mills.

Wood Hydrolysis—The production of wood sugars from wood waste (sawdust, shavings, edgings, etc.) by Scholler, Bergius, and other processes; the fermentation of wood sugars for the production of ethyl alcohol and other products; the utilization of the lignin of wood hydrolysis; the development of useful chemicals from wood waste by electro-chemical and micro-biological processes.

Wood Plastics—The investigation of new commercial adhesives and the laboratory development of special adhesives; the use of wood flour and lignin in plastics; the formulation and application of compregnated and other improved woods; the manufacture of various kinds of boards from wood paste with or without binders. Industrial application of wood plastics.

Wood Distillation—The manufacture of kiln and retort charcoal with and without recovery of by-products; destructive distillation of softwoods for recovery of pine tar, pine oil, etc.; steam and solvent distillation of softwoods; charcoal briquetting; metallurgical charcoal; activated carbon.

Chemical Extracts and Miscellaneous—Canada balsam; spruce gum; cedar leaf oils; pine needle oils; tannins; utilization of wood bark; insulating board.

Logging and Milling—Logging practices and equipment; the utilization of logging waste; sawmill practices and equipment, the economics of operation; the utilization of sawdust and other sawmill waste; lumber grading and standards.

Secondary Wood-using Industries—Planing mill practice and equipment; the manufacture of small dimension stock; pre-fabrication in housing and other structures; the relation of Building Codes to mill products; techniques in furniture manufacture; small woodenware industries as users of mill waste; exhibits.

Economic Studies—Integration of wood-using industries for more effecient utilization; silvicultural relations; trends in wood utilization; co-operation with industries and provinces in developing new techniques.

Lumber Seasoning—Factors controlling the efficiency of natural air-seasoning in different areas; design, operation and equipment control in dry-kilns; the seasoning of wood with chemicals; the control of moisture and temperature in wood-bending; vapour drying; degrade in lumber seasoning; moisture control for domestic and export shipments; moisture control in manufacturing and fabricating plants.

Pulp and Paper—Techniques in the manufacture of mechanical and chemical pulps; methods of testing pulps, and equipment for making tests; techniques in the manufacture of newsprint and other classes of paper, pulp-board, etc.; the utilization of waste pulp liquors; standardization of testing equipment; the utilization of waste wood for pulp and board; the utilization of bark; printing qualities of paper; methods and equipment for testing printing qualities; the utilization of cellulose, lignin and other wood constituents.

Wood Technology—The structure of different wood species and of foreign competing species; wood indentification (microscopic, photo-micrographic, etc.); properties in relation to uses for specific purposes; variation in density and other properties within a species; the significance of compression wood; defeats and their significance; chemical treatment for bark removal.

Methods of Operation

Investigations undertaken by the Forest Products Laboratories are of several kinds:

(1) **Investigations of general interest.** These may be initiated by the Laboratories or they may be suggested by an association or group in the wood-using industries. They are financed out of government appropriations to the Laboratories.

(2) **Investigations of limited interest.** These problems are generally suggested by a particular industry or even a company or individual. If it is decided that the problem is one which promises possibilities of

improving an existing situation or adding new and useful information to the wood-using industry it may be undertaken.

(3) **Special investigations for particular companies or individuals.** This refers to investigations where reports of results are for the sole use of the company or individual requesting the work. Only a very limited amount of such work is carried out. When it is undertaken a charge is made to cover direct outlay for salaries, materials, etc., and an additional charge is included to cover overhead.

(4) **Co-operative investigations**—A good deal of co-operative work is carried out with wood-using organizations. Many of these supply, at considerable expense, materials for the study and often additional technical assistance or labour. If it is decided that the proposed work is of value, the first question to be decided is whether the work is to be considered confidential in character. If it is not then the work may be undertaken by the Laboratories on the understanding that the Laboratories are quite free to publish the results of the investigation for the benefit of any who may be interested. Much valuable work of this character has been carried out through co-operation with lumber associations, government departments, public utility organizations and other organized bodies.

Types of Work

The Laboratories are primarily concerned with investigations having to do with improvement of products or of methods of manufacture, new uses for raw material and curtailment of waste in industry. This would suggest that the Laboratories are concerned principally with research which is largely industrial in character and this is the case up to a point. In carrying out an investigation which is primarily industrial in character, difficulty is very frequently encountered through lack of scientific or basic data required in the solution of the problem. For this reason a good deal of basic research is carried out.

A CONSIDERATION OF CERTAIN FACTORS AFFECTING THE TECHNICAL AND ECONOMIC POSITION OF PULP AND PAPER MILLS IN ONTARIO

A number of processes for the conversion of wood to pulp have been evolved over the years, each of these being particularly adapted to a certain wood species, or group of species, and each resulting in pulps of a type best adapted to a limited and specific group of end-uses. However, with improved techniques the properties of some of these pulps may be modified so that they are equal to, or even better than other pulps previously considered essential for certain products. The chemicals, steam and power required in conversion, and the yields of pulp and by-products are in each case somewhat different. Thus the manufacturer or prospective manufacturer is faced with extremely complex technical and economic problems in logically planning future developments in this field. Illustrating some of the points the accompanying chart shows the principal pulping processes, together with an indication of some of the various factors that enter into the economics of their manufacture. This chart is self-explanatory and will not be elaborated in the text.

At the present time the mills manufacturing chemical pulps in Ontario can be divided into two groups.

1. The older mills, using the sulfite process, these being largely located in southern and eastern Ontario, thus being a considerable distance from their wood supply, although relatively close to markets.

2. The newer mills, including those now being built, designed for use of the sulphate (kraft) process, these being largely located in western and northern Ontario, thus being close to their wood supply although at a distance from markets.

Generally a paper mill is located adjacent to a pulp mill which supplies at least a reasonable proportion of its fibrous raw material and such is found to be the case in most of the larger Ontario mills. In many of the older mills much of the equipment in either the pulp mill or the paper mill is approaching the stage of obsolescence. In both types of mill such obsolescence will result from the normal wear and tear coupled with the fact that equipment of modern design will give a greater production per unit of labour. In the older pulp mills the competitive position may at the same time be adversely affected by the high freight costs involved in bringing wood from a continually more distant area. When it is considered that a single paper machine of medium size will cost approximately a million dollars, it will be seen that the decision as to whether or not to modernize an apparently unfavourably situated mill cannot be taken lightly.

What are the factors which can improve the economic status of mills located in the more settled portions of the Province? First may be considered the development of by-products such as alcohol and yeast from the wood-sugars, plastics, and chemicals such as vanillin from the lignin, and products, yet to be established, from the bark. As the yield of saleable products per unit of wood increases, the advantage of proximity to markets approaches that of proximity to raw material. If through the development of by-products the economic position of mills regardless of zone becomes more nearly equalized a more stable industry may be attained.

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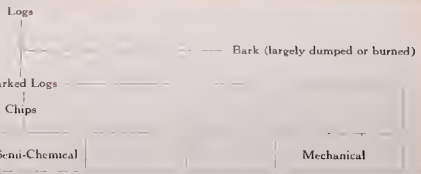

	Chemical Pulps		Semi-Chemical			Mechanical		
	Sulfate (Kraft)	Soda	Sulfite	Acid Sulfite	Neutral Sulfite	Steam Exploded	Asplund	Ground-wood
Wood—Referred Species.	Spruce, Balsam and other soft woods.	Poplar and other hard woods.	Spruce, Balsam, Hemlock.	Spruce, Balsam, Hemlock	Poplar and other hard woods.	Soft woods (scrap wood).	Coniferous	Coniferous.
Wood—Occasionally Used Species.	Hard woods	Soft woods.	Hard woods				Poplar	Poplar
Digestion Chemicals, lb/ton Pulp.	Salt cake (250-300 lb.).	Caustic Soda (80-150 lb.).	Sulfur (200-300 lb.). Limestone (300-350 lb.)	Sulfur (200-300 lb.). Limestone (300-350 lb.).	Sulfur (150-300 lb.). Soda Ash (150-300 lb.).			
Bleaching Chemicals.	Chlorine, Lime. Caustic, Soda.	Chlorine, Lime, Caustic, Soda.	Chlorine, Lime, Caustic, Soda.	Not bleached.	Chlorine, Lime. Caustic, Soda	Not bleached	Not bleached.	Hydrogen Peroxide.
Approximate Pulp Yield.	45-50%.	45-50%.	45-50%.	60-65%.	60-85%.	85-90%.	90%.	95%.
By-products. lb/ton Pulp. C—Commercial. L.C.—Limited Commercial. P.P.—Pilot Plant R.—Research	(C. Steam 12,000 lb.). R. Lignin (500-600 lb.). For use in plastics.	C. Steam 12,000 lb. L.C. Lignin (300-400 lb.). Used in plastics.	P.P. Steam (12,000 lb.) L.C. Vanillin (60-80 lb.). L.C. Alcohol (40-60 gal.). Road binder. Yeast.					
Chief Fibre Characteristics.	Excellent strength.	Good opacity and high bulk; medium strength.	Light coloured unbleached pulp; good strength; easy hydrating, suitable for conversion to rayon, etc.	Newsprint.	Good strength. Easy Hydrating.	Low strength unless hot-bonded in hydraulic press.	High bulk, low strength, unless hot-bonded in hydraulic press.	Low strength; good printing qualities; low colour.
Major Pulp Uses, unbleached.	Wrapping papers, corrugating papers, building papers.		Newsprint. Box-board	Newsprint.		Hardboard	Roofing-felt Hardboard.	Newsprint. Insulating wallboard.
Major Pulp Uses, bleached	Bonds and printing papers.	Book paper; mimeograph; blotting	Bond book paper; Glassine. Rayon.		Book paper. Glassine.			Book paper.
Present Status of Industry.	Relatively low production costs, versatility with regard to wood and good strength make this attractive process for present new installations Very rapid expansion now under way.	Long established process for "speciality" pulp used in relatively small quantities. Little expansion visualized.	Long established and important process. Little expansion at present time. Full commercial development of "waste sulfite liquor" utilization should result in considerable stimulus to industry	Modification of normal sulfite process to give higher yield for newsprint.	Largely in experimental stages. Because of high yield and good strength from deciduous wood, process should become increasingly important	Demand for structural fibreboard should result in increased production of Masonite type products.	Process used for specialized purposes such as roofing felt, building board, etc.	Long established process for newsprint. Recent development of bleached groundwood printing papers should result in expansion of industry.

Another factor which should be considered is the greater utilization of hard-woods including fast growing species such as the hybrid poplar. Trees of this type should be available from farm wood lots on a continuing crop basis. An efficient reforestation programme for the farmers would also have obvious advantages from the standpoint of soil conservation and flood control. The commercial utilization of such species is at present extremely limited but laboratory work has indicated that the so-called semi-chemical hard-wood pulps may have properties which compare favourably with those of the pulps from spruce. Considerable research directed towards economy in processing and also with regard to the quality obtainable from the fast growing hybrid species is required before any wide spread development can be expected.

Unless or until the mills of southern and eastern Ontario can feel assured of a favourable economic position, long range planned improvement is likely to be delayed or neglected with the result that their condition may deteriorate to the point where they will be forced to close as has been the case with several American mills.

This brief survey has outlined some of the factors which may influence future trends in the industry. Co-ordination of these trends and definition of the ends that may be attained can have a profound influence on the future of the industry and through it on the prosperity of the Province.

FOREST RESEARCH—DEPARTMENT OF LANDS AND FORESTS

GENERAL PROBLEM

I. Regeneration

(a) Natural

(i) Regeneration Survey. This survey is being carried out on burned and cut over areas of different ages and sites throughout the Province of Ontario to determine present stocking and to study those factors favourable or detrimental to the establishment and survival of regeneration, e.g., seed supply, seed bed condition, soil moisture, exposure, etc. This survey should, where possible, give consideration to developing a simple method of site identification on cut over areas so that site classification may be carried on. Also an attempt should be made to determine the natural successions of plant communities on different sites, the stage in succession producing the most economically valuable community and the factors affecting its establishment.

(ii) It is believed that certain logging methods are unfavourable to regeneration and, although a great deal of basic information on this subject is still lacking, it seems probable that for some species a modification of present logging methods would result in more satisfactory regeneration. More specifically, studies should be made on the occurrence of seed years for the more important commercial species and to determine the possibilities of modifying present logging methods with the object of minimizing damage to advance growth and the creation of favourable seed bed conditions. It is recommended that the surveys on forest regeneration be continued in Ontario similar to the ones being carried out by the Dominion Forest Service in other provinces.

(iii) Since insects and other destructive agents are known in some cases to destroy a large percentage of the seedlings produced under natural conditions, some estimat‹ of their importance in various forest environments would be necessary in a survey of this sort.

(b) Artificial

Artificial regeneration may be carried out on recently cut over or burned areas, on areas where competitive growth is well established and on open land sub-marginal for agriculture where the possibilities of planting machines may be developed. The following are some of the main specific problems that should be studied under this general heading:

(1) Large-scale collection of seed (methods and procedures).

(2) Determination of site quality.

(3) Preparation of site, methods and time for planting or sowing.

(4) Seed treatment to increase survival of seedlings.

(5) Development of superior strains of economic species.

II. Protection

(a) Fire

(a) Investigation of actual and allowable forest losses in Ontario; allowable loss to be defined as loss whose prevention-costs exceed the values saved.

(2) Investigations to improve fire prevention equipment including (a) lookout towers and equipment and (b) aircraft.

(3) Investigations to improve fire suppression equipment including (a) pumps, hose and nozzles, etc. (b) fire line construction machines (c) special vehicles and aircraft.

(4) Investigations on fire weather forecasting in forest protection should be undertaken in Ontario along the lines of the work already done by the Dominion Forest Service in New Brunswick, Quebec, Saskatchewan and the National Parks of Canada.

(b) Biological

(1) Investigation of white pine blister rust.

(2) Investigation of red stain and butt rot in jack pine.

(3) Investigations of cone destroying insects.

(4) Investigations of heart rot of poplar.

(5) Investigation of insecticidal spraying by aircraft and from the ground.

(c) General

(1) Investigations of smelter fume damage to white and red pine.

III. Surveying

(a) Investigation of radar methods "Shoran", etc., to provide ground control for aerial surveys.

(b) Development of specialized photo interpretive equipment for forest type mapping.

(c) Investigation of special films for forest type mapping.

(d) Establishment of survey photographic library at some central point in Ontario to include all Ontorio survey photo prints.

(e) Studies to integrate more effectively aerial and ground survey information.

IV. Utilization

(a) Investigation into the possibilities of encouraging the co-operation and co-ordination of the activities of the several branches of the wood-using industries with a view to assuring the best economic use of the whole product of the forest.

(b) Investigation into the possibilities of improving sawmill practice. It is known that many sawmills, especially among the smaller units, use practices which result in a great deal of waste and which may not be making the best use of their raw material. Such a study should give consideration to European practices and their practicability in Canada.

(c) Chemical Utilization—Wood has been extensively used for chemical pulp and in wood distillation. Otherwise its use as a raw material for chemical products has received insufficient attention. In view of the very large amounts of waste in both mills and in the woods, much greater attention is required to processing it by hydrolysis, microbiological action and other such means. Much greater attention is also required to the study of lignin and cellulose derivatives. Universities should be encouraged to do basic work in this field and to supply trained workers to supplement the staffs and organizations already engaged in this type of work.

(d) Investigations into possible methods of utilizing the waste resulting from logging operations. Such an investigation should include both a study of possible uses for this material and a study of the transportation and other extractive problems involved.

(e) Utilization of Poplar—Interest in the use of poplar is widespread but nothing in published form is available for the use of owners of poplar stands. Its use for lumber, pulp and plywood is increasing. Steps should be taken to assemble and publish as soon as possible up-to-date information on this subject. A knowledge as to the potentiality of hybrid poplar species from the standpoint of their adaptability for various uses as well as their value in reforestation of marginal agricultural lands is also required.

(f) Red Stain in Jack Pine—Studies should be carried out on the utilization of this stained material by co-operation with organizations which already have this matter in hand.

(g) Selection and preservation of mine timber.

V. Forests and Water Supply

Investigation of the relation between forest cover and water supply, surface and subsurface. Study of data secured and reports prepared in Canada and elsewhere. Initiation of collection and study of pertinent field data in specific areas of the Province, including precipitation, stream flow, subsurface storage, soils, and forest cover.

VI. Research and Training of Research Personnel

Present facilities for research and for training research personnel at the graduate level are entirely inadequate for research and for the supply of men to carry out the projects contemplated by various Government agencies. Greatly increased facilities for research and for the training of such men by the universities concerned are therefore urgently needed in various phases of forest biology. If the universities are unable to take the steps necessary for the training of these men, direct action by the Commission to provide the necessary space and facilities is suggested.

RECOMMENDED PROJECTS—FORSTRY RESEARCH—1947-48

Title	Agency	Capital	Operating	Total
Wood Chemistry	Ontario Research Foundation	$2,000.00	$18,000.00	$20,000.00
Forest Regeneration and Management in Woodlots and Rocky Regions	Queen's University	.....	1,590.00	1,590.00
Unclassified as yet (for Sawmill practice research)		.....	.....	25,000.00
		$2,000.00	$19,590.00	$46,590.00

COMMITTEE ON AGRICULTURAL RESEARCH

Meetings—

Informal	July 9th, 1946	Ontario Agricultural College
	July 10th, 1946	With Ontario Research Commission
Advisory Committee	Sept. 9th, 1946	Ontario Agricultural College
" "	Dec. 16th, 1946	" " "

Committee—

Mr. K. Betzner	Kitchener, Ont.
Mr. Gordon Blair	Niagara Spray Co., Burlington
Dr. H. D. Branion	Ontario Agricultural College
Professor C. G. E. Downing	Ontario Agricultural College
Professor E. H. Garrard	Ontario Agricultural College
Dr. E. S. Hopkins	Central Experimental Farm, Ottawa
Mr. L. Kerr	Chatham, Ont.
Professor R. G. Knox	Ontario Agricultural College
Mr. C. F. Luckham	St. Williams
Dr. A. L. MacNabb	Ontario Veterinary College
Mr. M. H. McCurdy	Cockshutt Plow Co., Brantford
Dr. G. P. McRostie	Ontario Agricultural College
Mr. E. F. Palmer	Horticultural Experiment Stn., Vineland
Mr. K. Neatby	Department of Agriculture, Ottawa
Mr. Arnold Pitt	Massey-Harris Limited
Mr. F. W. Presant	Toronto Elevators Limited
Professor C. N. Ruhnke	Ontario Agricultural College
Mr. G. Schell	Canada Packers Limited
Mr. J. C. Steckley	Experimental Farm, Ridgetown
Mr. W. G. Toner	Royal Dairy Products, Guelph
Mr. S. B. Trainer	Silverwoods Dairy
Mr. George Wilson	Department of Agriculture, Ontario
Mr. S. M. Young	International Harvester

BRIEF OF THE ADVISORY COMMITTEE ON AGRICULTURAL RESEARCH TO THE ONTARIO RESEARCH COMMISSION

1. INTRODUCTION

Research in agriculture is so well-established, and has made such significant contributions to the welfare of the Dominion and of the Province, that no justification of a research programme is required. No one can live in any part of Canada for even a short time without being made aware of the tremendous ramifications of agricultural research, and no one questions its place in the greatest of Canada's primary industries. While the achievements are probably less spectacular than those possible in other fields, and may be the results of tedious years of rather dreary investigations, nevertheless, the value to the community is so great that there is a universal desire to maintain the present agencies for research, and probably quite general endorsation of a reasonable extension of their activities. People remember what the breeding of Marquis wheat meant in the development of the West, and appreciate what the new rust-resistant cereal crops mean and will mean to the Dominion. Similar significant accomplishments have made the work of the fruit-grower, the tobacco-farmer, the bee-keeper, the stock-breeder, the dairyman—in short, all those engaged in agricultural production—much easier and much more profitable. In fact, the improvements in methods and standards of production directly attributable to research and extension have so altered agriculture that the changes effected may best be described as "revolutionary".

Co-ordination

Despite the fact that there is a multiplicity of agencies engaged in agricultural research, there has been surprisingly little conflict or outright duplication of effort. It is true that research on a particular problem may have commanded the attention of several agencies at one time, but the avenues to be explored were many, and, through the exchange of information, surprisingly little duplication occurred. This co-ordination of effort by the Dominion Department of Agriculture, the Provincial Departments of Agriculture, the universities and colleges, the research foundations and the National Research Council, has been evident in all branches and at all levels, and has been carried out through advisory and associate committees, through frank and complete exchange of information and through a general division of the work.

Beginnings of Research

Immediately after Confederation the Dominion Parliament embarked on a regular programme of agricultural service, and within twenty years had set up numerous divisions, each charged with the responsibility for research and extension in a particular field. During the same period provincial programmes of research and extension were developing just as rapidly and just as efficiently. For the most part, the provinces worked through the provincial universities, colleges and foundations, through agricultural representatives and through producers' organizations or individual producers. The work accomplished over the years has won for provincial Departments of Agriculture and their associates prestige and prominence equivalent to that enjoyed in the industry by the Dominion Department of Agriculture, and, while it is impossible to enumerate

the contributions made, it should be pointed out that those contributions were particularly important in the fields of soils problems, crop production, animal production and the marketing of farm products.

Special Feature of Agricultural Research

The notable feature in agricultural research, a feature which sets it more or less apart from research in other fields, is that activity commonly known as extension work, which must be an integral part of practically every project. Since knowledge gained in the laboratory, the college plot or the experimental farm is of value only when made known to the "practical farmer", and since the vast majority of these are rugged individualists, the agencies interested in agricultural welfare and progress must carry on their extension work constantly.

Types of Research

Agricultural research, to be worthwhile, must cover the basic needs of production and of utilization. Research on production is well-established, and existing facilities, with some expansion, are competent to meet any likely problem in this field, which includes soils surveys and proper land-use, plant production and improvement and animal production and improvement, each with its host of related topics and its extension programme. Far less attention has been paid to utilization. Of late years the needs in this field have been recognized and some start has been made on an overall programme. It is recognized that the Dominion Government has a primary responsibility in this field, and is much better-equipped to promote the proposed campaign, but considerable contribution might be made by the Province. The importance to any industry of the utilization of its products requires no elaborotion, and since agricultural production represents the work of hundreds of thousands of individuals, research leading to the maintenance of markets for that production must, of necessity, be a public responsibility. That research, which must be a major effort, includes the whole problem of markets with all the ramifications of world-trade problems, facilities for marketing, transportation, processing, industrial utilization of farm products and nutrition. It includes, as well, research on land-settlement, farm credits, stabilized prices, farm labour, together with consideration of farm amenities and cultural activities. Agriculture, to be permanently progressive and remuneratively attractive, must be efficiently productive in regard to both quality and quantity of its products. It follows, surely, that agricultural research must have continuity and must be attractive to qualified personnel.

2. GENERAL STATEMENT

The Advisory Committee on Agricultural Research has received reports of the four Sub-Committees appointed to explore the status of agricultural research in Ontario. Copies of these reports have been submitted. The Comittee has reached the following general conclusions with respect to the work which has been done so far by the Sub-Committees.

(1) These reports do not present a complete inventory of the research under way by the several departments involved. Such a statement would be voluminous, and it has not been found desirable to request already overburdened staffs to prepare such material. Copies of the reports submitted at the July meeting at the Ontario Agricultural College are on file with the Ontario Research Commission.

(2) These reports do not present lists of all the new projects which agricultural research officers feel should be undertaken. The establishment of such lists with indications of the relative urgency with which various projects should be undertaken would involve consultations on the part of many groups of specialists, and an over-all appraisal of the relative importance of each, which the main Committee does not feel competent to undertake.

(3) Reports of the Sub-Committees have presented a cross section in the field of agricultural research in Ontario from which the Committee has been able to form an expression of opinion on the relative importance of the general lines of work under way, and the need for increased support to certain fields which have not received adequate attention or in which new possibilities have become apparent because of recent advances in science. While certain projects have been indicated as having high priority, this does not mean that other projects not so emphasized should not continue where facilities and personnel are available.

3. SUMMARY OF FINDINGS OF SUB-COMMITTEES

The main Committee presents the following general summary of the findings of the four Sub-Committees and the discussions in the main Committee:

SOILS RESEARCH

The basis of profitable farming is soil fertility. The store of fertility accumulated over centuries of weathering and plant and animal decay is becoming depleted through use and neglect. No field of research is more important to Ontario agriculture. For details of the type of research which are presently under investigation see Appendix "F", part of Appendices "D" and "E", and Appendix "G" to the report of the meeting of July 10th at the Ontario Agricultural College. For details of the field of Soil Microbiology see pages 6 to 11 of Appendix "B", the report of the Sub-Committee on Animal Husbandry, Soils, Plant and Animal Diseases, Field Husbandry and Animal Nutrition. The Committee also has reviewed the brief of the Advisory Committee on Soils Research. It will be observed that the projects which relate to agriculture in the report of the Advisory Committee on Soils Research are also stressed in this report.

(a) Surveys

Soil surveys are presently under way and must be all-inclusive, namely: typing, mapping and, of more immediate practical value, testing for suitability and requirements of various crops. These surveys should be continued and expanded. They are all important to a sound agriculture.

(b) Conservation

Much more extensive research is needed in all the fields which contribute to the establishment of a sound soil conservation programme for the Province. A continuation of the farm planning service and of the studies of erosion and run-off needs marked expansion.

(c) Microbiology

It is recommended that more fundamental studies be initiated in the field of microbiology. It is increasingly evident that the active stages of decomposition of green manuring crops are at least partly responsible for satisfactory crop growth and fruitfulness. Crops respond variously to varying soil treatments. The physical and microbiological condition of soils needs to be studied intensively in relation to crop performance, incidence of disease, permanence of soil use. More fundamental knowledge would eliminate many costly trial and error experiments. Results of pot and greenhouse experiments of the past have been helpful, but we suggest future work should be planned to include co-ordinated, wider and more practical lines of research in microbiology. The need for such investigations is recognized and they are being initiated.

(d) Structure and Fertility

It is recommended that further study be given to the fundamental problem of soil structure as influenced by tillage, by crop residues and the application of fertilizers.

The profitable use of fertilizers for various crops and on different soils and the best forms of fertilizer needs much study both for use on different soil types and in various parts of the Province.

The problems presently under investigation are of both fundamental and practical natures and should be continued. In fact, the suggestions, outlined above, are, in effect, an expansion of these studies.

(e) Tillage and Machinery

Tillage machinery, when used, has a distinct effect on the physical structure of the soil. This structure and tilth may be further affected by rotation of crops, drainage and other physical cultural factors. Limited experimentation has been conducted on standard implements and cultural practices. Research must be instigated to evaluate introductory types of equipment, the effect of speed, depth and application of any machines on the required conditions of the soil for various types of crops.

PLANT PRODUCTION

Plants transform the raw materials of the soil and air into food for domestic animals, poultry and man. The story of the steady advancement of agriculture has been that of constant diversification in the production of plants, their protection against disease and pests and their increased utilization by man for food, clothing and feeding of domestic animsls. This process is still going on, intensified by the wearing out of soils, the increase of disease and pests which attack plants forced beyond their natural conditions of growth, and the necessity for economic production in a commercialized agriculture. The maintenance of an adequate research programme in plant production is, therefore, essential in Ontario. For details of the type of research presently under investigation see Appendices "A", "B", "C", part of "D" and "E", "I", "J", "K", "L" and "M" and part of Appendix "S" to the report of the meeting July 10th at the Ontario Agricultural College.*

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*Copies on file at—
(1) Ontario Research Commission, 43 Queen's Park.
(2) Legislative Library, Parliament Bldgs., Queen's Park.
(3) Library, Ontario Agricultural College, Guelph.

(a) **Breeding and Variety Testing**

Extensive enlargement of the field of plant breeding as applied to general farm crops, to pasture crops, and to many of the horticultural and specialty crops is most necessary. The breeding programme being conducted at present is quite extensive with winter wheat, oats, soybeans, field beans, barley, potatoes, and some fifteen species of grasses and legumes. Limited breeding is being done with practically all other types of field crops commonly grown in Ontario. Comprehensive breeding and variety trials of fruits and vegetables and some specialty crops are being conducted. In all such work consideration must be given to disease resistance, yield, quality, hardiness, market acceptability, etcetera. The nutritive value of the crops, either for animal or human consumption, is and must be given due consideration.

(b) **Nutrition**

The nutrition of plants embraces many other fields of research such as soils, fertilizers, cultural practices, climatology and so on. In this broad field, continuation of and expansion, when possible, of the research in these various phases, will contribute to the knowledge of plant nutritive requirements. However, only a limited amount of work is being carried on in the specialized field of determination of the exact plant nutrient requirements and their interrelationships, as well as the specific requirements of some specialized crops. This fundamental field could be expanded advantageously.

(c) **Cultural Studies**

The culture of farm crops, horticultural crops, and specialty crops comprises a very broad field of study. The studies include the influence on yield and quality of the size and plumpness of seed sown, dates of seeding, rates of seeding, etcetera. In horticultural crops culture has a profound effect on their ability to withstand storage.

Research in this field involves transportation and marketing, as well as yield of farm products and no hard and fast lines of demarkation can be drawn.

(d) **Control of Pests and Diseases**

New insecticides, fungicides and weed killers are appearing on the market, together with equipment and suggested methods for their application. Studies of the practical value of these chemicals and the effectiveness of the equipment and methods of application have been undertaken and must be continued and probably expanded, to determine their usefulness in the control of pests and diseases in fruit, field and garden crops. Continued work with the older, established products and control measures must be maintained at present.

It would seem advisable to initiate more fundamental research on (1) plant insecticides (fruit, field, greenhouse and garden crops, shade and forest trees), (2) fumigants and insecticides, (3) fungicides and seed disinfectants and (4) herbicides. Further, it must be borne in mind that biological studies including taxonomy and anatomy, of various groups and species of insects, etcetera, of economic importance must not be disregarded.

Investigation of numerous plant diseases of the various types, such as water core in rutabagas, virus diseases of stone fruits, pepper, celery, cucumber, tomato and tobacco, fusarium disease of asparagus, bacterial and virus diseases of soybeans, black root disease of sugar beets, nematodes, etc., is being con-

ducted. Such investigations also embrace several allied fields of work, but in particular emphasize the need for continued and expanded research in the fields of plant physiology and phytopathology.

This field of control and eradication, where possible, of plant diseases, of weeds and harmful insects, etc., must continue to be co-ordinated with other fields of agricultural production.

(e) Harvesting and Machinery

Mechanization may be utilized to improve quality, quantity and efficiency of plant production by proper harvesting and crop handling methods and equipment. It is recommended that investigations be conducted to determine the suitability and practicability of introductory as well as standard types of equipment in the planting, handling and harvesting of crops. These investgiations must be co-ordinated with studies as to yield and nutritive value of plants and crops as determined and recommended by plant breeders, animal husbandmen and nutritionists. The production and handling of hay to maintain high quality with a minimum loss of nutrients is worthy of more extensive study. Expansion of investigations in this field merit every assistance.

The improvement of pasture which involves investigation of soil fertility, management, plant breeding, nutritive value, etc., has been the subject of much study and resultant valuable contributions to agriculture. Nevertheless, the problems are by no means solved and continued investigations in this field are of paramount importance.

LIVESTOCK AND POULTRY PRODUCTION

As human communities pass from predominantly pastoral to industrial areas, livestock and poultry production play an increasingly important part in the agricultural economy. Ontario, with its diversification of crops for animal feeding, a temperate climate, domestic market among industrial workers, and access to export markets, will continue to expand its livestock industry. Livestock and poultry, on a large proportion of the farms in this Province, are the main products through which crops are marketed, and the value of a sound soil fertility programme and the production of good crops will be wasted unless the quality of the livestock and poultry is high.

For a detailed presentation of this field see Appendices "N", "O", "P", "Q", "R", part of "S", "T" and part of "U" to the report of the July meeting at the Ontario Agricultural College.*

(a) Breeding

Excellent progress has been made over a period of years in establishing specific types of swine, sheep, beef and dairy cattle suitable for the profitable production of meat, milk and wool. Such investigational work is valuable and necessary and must be continued, if such types are to be maintained and improved. However, it would appear that the time has come when research on such fundamentals as mode of inheritance of muscle tissue from the standpoint of carcass quality in bacon, mutton and beef production, isolation and establishment of families and investigation of the mode of inheritance in these strains

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(2) Legislative Library, Parliament Bldgs., Queen's Park.
(3) Library, Ontario Agricultural College, Guelph.

of economy of feed utilization, etc., must be undertaken. It is strongly recommended that such basic genetic research be instigated and prosecuted to the fullest possible extent. Similar studies with chickens and turkeys are essential.

Research into various problems associated with artificial insemination, such as transportation, effect of dilutants, temperature, motility of semen and many other phases should be continued. This method of breeding is continuing to expand, and expansion always raises new problems which must be solved.

Investigation of the mode of inheritance of abnormalities such as cryptorchidism, herniae, etc., is worthy of special note. Such conditions resulted in an estimated loss of 65 to 75 thousand dollars in 1945 to the pig breeders of this Province.

(b) Nutrition

The study of the nutrition of livestock and poultry is a central field in agricultural research. Not only is the practice of good animal nutrition the means to a financial end, but the achievement of good human nutrition through the production and proper utilization of agricultural food products, adequate in both quantity and quality, is a very important end in itself. Knowledge of animal nutrition has many implications and applications in the field of human nutrition. Hence, there is a vital interrelationship between medical and social sciences and those sciences which are conventionally considered agricultural.

Investigations into some phases of the many aspects of the fundamental nutritive requirement of the various classes and types of livestock and poultry, together with practical feeding problems and establishment of economic rations suitable for the production of quality products have been and are under study. Many factors such as intensified production, feed substitutions, have tended to accentuate the need of nutritional research both practical and fundamental. The field is continually expanding as new factors are isolated, as new investigational and bio-assay techniques become available and as new problems arise as a result of changes in soil fertility, new methods of production, etc. The scope and intensity of this work is not adequate to meet present needs.

There is no doubt that nutritional investigations must continue and it is recommended that expansion be facilitated, particularly in the livestock field.

(c) Disease Control

Of all the factors which may contribute to losses in livestock and poultry, disease, either infectious or nutritional, would stand at the top of the list. It has been reported, as a result of a recent survey, that 23 per cent of the pigs born in a given period of time, died before weaning.

Research, including causes, treatment and control measures, into such diseases as mastitis in dairy cattle, abortion disease (bovine brucellosis), rhinitis in swine, horse cholera and encephalomyelitis, various diseases of fur-bearing animals, salmonella infections in poultry, disinfection of incubators, etc., are being steadily prosecuted. All such studies should be continued and expanded as facilities warrant.

Investigation of the control of such insects as warble flies, horn flies and other blood-sucking flies, lice, house and stable flies, etc., is being carried on. Such studies are not only important from the standpoint of economic livestock production but they also involve studies of the suitability, methods of application and chemistry of newer insecticides.

(d) **Buildings and Machinery**

There is an urgent need for investigational work and research in the designing, planning, remodelling of farm buildings on a proper functional basis. This applies not only to buildings in which the larger farm animals are housed but to poultry housing as well.

Similarly, there is a need for designing, re-designing, manufacturing and testing of farm equipment under the general heading of labour saving-devices. This is an important means of increasing farmers' labour efficiency.

(e) **Apiculture**

Many of the problems in breeding, feeding and disease in livestock and poultry production have counterparts in the field of apiculture. Studies of queen rearing and breeding, types of food for brood and queen rearing, diseases such as foulbrood, nosema, etc., are being carried out. Such studies should be continued and must not be overlooked, as honey production is an integral part of Ontario agriculture, to say nothing of the role of bees in pollination.

AGRICULTURAL ECONOMICS, FARM ORGANIZATION AND MARKETING

One of the limiting factors in the rapid improvement of agriculture in Ontario is the farmer himself. In contrast to industry, he is, to a large extent, his own labourer, foreman, production manager and sales manager. To expect any more than a limited number of men to combine all the qualifications necessary to understand the basic principles of soil management, crop production, animal production and farm management is to expect too much. Research in farm management and the marketing of agricultural products is essential, both from the point of view of the individual farmer and the legislator and administrator who is responsible for the development and guidance of agricultural policies.

Better farm management would mean more efficient or lower cost production which would permit more satisfactory price competition of all farm products on domestic or foreign markets. The marketing field is a major part of our general agricultural economy. A study of the methods of co-operative and non-co-operative agencies operating in the various fields would yield information on the best marketing methods and, at the same time, give information on the requirements for maintenance and expansion of domestic and export markets.

In addition, continued study of the production costs of agricultural products such as meat, milk, eggs, cereals, fruits, vegetables, etc., must be maintained. Such studies necessarily involve correlation with efficiency of production.

Marketing involves such factors as packaging, improvement of quality, processing, storage and refrigeration, development of manufacturing methods for new products and so on. The nutritional value of the product must not be disregarded. It hardly need be pointed out that marketing involves every branch of production and, again, no line can be drawn between marketing and production.

It would seem that this phase of agricultural research could be enlarged with resultant benefit. Almost every agricultural product involves its own specific marketing problems.

The possible utilization of agricultural products and by-products in new industrial fields warrants further investigation.

For further details see Appendices "V" and "W" and parts of Appendices "E" and "U", of the July meeting at the Ontario Agricultural College.*

CONTINUITY OF RESEARCH PROGRAMMES

It must be obvious to anyone who has studied the reports of the Sub-Committees and of the July meeting at the Ontario Agricultural College that many of the problems are basic and that a sound programme for Ontario agriculture cannot be maintained unless these problems are solved. Many of these are long-time problems. Continuity of support is essential to their solution.

All Sub-Committees are agreed that such continuity involves both finances and personnel. It is recommended that a Research Fund, to be administered through the usual Government channels, should be established in continuity, adequate to permit various necessary projects to be pursued as personnel and facilities are available.

EXTENSION AND PUBLICITY

It is of no use for the research worker to solve an agricultural problem and lock up the answer in his files, or, at most, to record it in a scientific journal to be placed on the shelves of libraries. The solution of a problem must be carried through to farm practice and that particular part of farm practice must fit into a sound programme of farm management. It will be useless to expand agricultural research unless the machinery is functioning which will teach the farmer how to apply the solution worked out by the scientist.

4. ORGANIZATION AND MAINTENANCE OF SERVICES

APPRECIATION OF THE PROBLEM

(a) No industry is as well organized as agriculture from the point of view of research facilities, extension services, and legislative machinery to cope with the basic problems of the industry. The temporary limiting factors in the carrying out of a more extensive programme are additional personnel, equipment, and space. Adequate funds to correct this situation will be secured through the regular channels.

(b) Problems tend to come to the established and recognized agricultural institutions due to their direct contacts with the farming public, their close association with the Agricultural Representative Service, and with graduates of the Agricultural College, in practical farming and industries allied to agriculture.

(c) It is the duty of all branches of the agricultural services to anticipate problems. Further, two specific non-research units, namely: the Plant Protection Division and the Health of Animals Division of the Dominion Department of Agriculture, are charged with the responsibility of preventing the entry of plant and animal pests and diseases into Canada.

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*Copies on file at—
(1) Ontario Research Commission, 43 Queen's Park.
(2) Legislative Library, Parliament Bldgs., Queen's Park.
(3) Library, Ontario Agricultural College, Guelph.

(d) The teaching and extension in agriculture being major activities of agricultural institutions, staff, equipment, library facilities, etc., are basically suitable for the conduct of agricultural research. Moreover, a research programme is vital to teaching and extension and especially for post-graduate studies to maintain the supply of well-trained personnel.

(e) Your Committee is of the opinion that the field of agricultural research can be adequately served by the Ontario Agricultural College, Ontario Veterinary College, Provincial Experimental Stations and the Dominion Department of Agriculture, and to a certain extent by research units in the Ontario Research Foundation and the National Research Council. It is felt that other university Faculties of Science in the Province should not be engaged in agricultural research per se, but should confine their activities to co-operation with the above agencies on specific phases of agricultural research problems, and to assist in the training of post-graduate students who require the special courses and facilities available for the particular training required. The Committee feels that such students' courses and thesis projects should be discussed with recognized agricultural research authorities in the field in which the student expects to work.

(f) The Committee feels that it is impossible to draw hard and fast lines allocating specific fields of research to various institutions. It is not possible to allocate fundamental research, so-called, to one institution and applied research or experimentation and investigation to another. Actually, all types of problems are referred by the public to all institutions concerned, and in practice the research workers divide and allocate the work according to personnel and facilities available.

CO-ORDINATION OF EFFORT

In spite of the numerous units of federal and provincial agencies engaged in agricultural work, the Committee finds a large measure of co-ordination and little or no unnecessary duplication in research.

In two limited fields, namely Phytopathology and some phases of Bacteriology, the Committee agrees that closer co-ordination would be advantageous. The workers in these two fields are aware of the situation and the necessary corrective steps are being taken.

Appendices "H" and "Y" to the report of the July meeting at the Ontario Agricultural College* give a resume of the research services of the Dominion Department of Agriculture. Appendix "Y", subsequently prepared by Science Service, Dominion Department of Agriculture, gives a concise picture of the research in the various divisions of this Service. A book entitled "The Dominion Experimental Farms" gives a complete story of this Branch.

The following are some examples of co-operation and co-ordination between federal and provincial services:

(a) **National Committees**

National Committee on Agricultural Engineering.

National Agricultural Outlook Committee.

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*Copies on file at—
(1) Ontario Research Commission, 43 Queen's Park.
(2) Legislative Library, Parliament Bldgs., Queen's Park.
(3) Library, Ontario Agriculture College, Guelph.

National Barley and Linseed Flax Committee.

National Beef Cattle Committee

National Feed Committee.

National Sheep Committee.

National Committee on Soil Conservation.

National Soil Survey Committee.

National Weed Committee.

National Seed Grain Committee (being abolished).

National Dairy Cattle Committee (being organized).

National Swine Committee (being organized).

(b) **Federal-Ontario Committees**

Corn Committee

Winter Wheat Committee.

Soybean Committee.

Pasture Committee.

Soil Survey Committee.

Potato Investigation Committee.

Ontario Fruit and Vegetable Spray Service.

Tobacco Fertilizer Committee.

Sugar Beet Nematode Committee.

Ontario Feed Board.

Ontario Fertilizer Board.

Ontario Crop Improvement Association.

Committee of Ontario Bee-Keepers Association.

(c) **Interdepartmental Committees and Conferences**

Ontario Dairy Research Council.

Pullorum Conference.

Feedstuffs Act—Sub-Committees on Vitamins, Minerals, etc.

Ontario Poultry Industries Committee.

Joint Studies and Control (Corn Borer,Cutworm, Nematode, Japanese Beetle, Dutch Elm Disease, etc.).

Co-operative Crop Testing Committee (apportioning of test work on area basis).

TYPICAL CURRENT CO-OPERATIVE PROJECTS*

(a) Dominion Projects

Breeding of disease resistant varieties of farm crops, including the introduction into Ontario of plant breeding material from foreign countries.

(Experimental Farm—Forage Crops, Cereals, Horticulture; Science Service—Botany and Plant Pathology).

Pregnancy testing of mares.

(Experimental Farm—Animal Husbandry; Science Service—Chemistry).

Tattooing registration numbers on live stock.

(Experimental Farm—Animal Husbandry; Science Service—Chemistry).

Pullorum control in poultry.

(Experimental Farm—Poultry; Science Service—Animal Pathology).

Mastitis of dairy cattle.

(Experimental Farm—Animal Husbandry; Science Service—Animal Pathology).

Bacterial ring rot of potatoes.

(Science Service—Plant Pathology and Plant Protection).

Fertilizer experiments on a wide variety of crops.

(Experimental Farm Divisions; Science Service—Chemistry).

(b) Dominion-Ontario Projects

Potato production—tillage, fertilizers, etc.

(Experimental Farm; Ontario Agricultural College).

Potato spraying—disease and insects.

(Science Service; Provincial Entomologist.)

Soil Survey.

(Experimental Farm; Soils Department, Ontario Agricultural College.)

Sugar Beet Nematode

(Science Service; Provincial Entomologist.)

Spray calendars.

(Science Service; Ontario Agricultural College; Fruit Branch.)

Tobacco Production—varieties, fertilizers, disease and insects.

(Experimental Farm; Science Service; Ontario Agricultural College.)

Sugar Beet Diseases.

(Experimental Farm; Science Service; Ontario Agricultural College.)

Alsike Clover Production.

(Experimental Farm; Science Service; Ontario Agricultural College.)

Pullorum disease of Poultry

(Science Service; Ontario Agricultural College; Ontario Veterinary College.)

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*For details of these and numerous other projects already reported, see report of Ontario Research Commission Meeting, July 10th, 1946, at the Ontario Agricultural College, Guelph. **

**Copies on file at—

(1) Ontario Research Commission, 43 Queen's Park.
(2) Legislative Library, Parliament Buildings, Queen's Park.
(3) Library, Odtario Agricultural College, Guelph.

Vitamin D Studies.

(Science Service; Experimental Farm; Ontario Agricultural College.)

(c) Provincial Projects

Livestock diseases—mastitis, calfhood vaccination in Bang's disease, rhinitis in swine.

(Ontario Veterinary College; Animal Husbandry, Ontario Agricultural College.)

Forage crops—varietal tests, nutrient content.

(Ontario Agricultural College, Field Husbandry, Animal Husbandry, Animal Nutrition; Ontario Pasture Committee.)

Grain and seed—malting barley, soybeans, winter wheat.

(Ontario Agricultural College, Field Husbandry; Canada Malting Co.; Brewers' Warehousing Co.; Toronto Elevators; Maple Leaf Milling Co.)

Weed control—chemical killers.

(Ontario Agricultural College, Botany, Field Husbandry, Horticulture, Ontario Crops, Weeds and Seeds Branch; Dominon Rubber Co.)

Insecticides and fungicides.

(Ontario Agricultural College, Entomology, Botany, Animal Husbandry.)

Dairy Products—Vitamin A activity of butter, flavour of butter, retention of nutrients in cheese.

(Ontario Agricultural College, Dairy, Chemistry, Bacteriology, Animal Nutrition; Hospital for Sick Children, Toronto; Dairy Branch, Ontario Department of Agriculture.)

Non-specific seriological pullorum reactions.

(Bacteriology and Poultry Departments, Ontario Agricultural College.)

Turnip Breeding and Testing.

(Botany, Bacteriology, Entomology, Field Husbandry Departments, Ontario Agricultural College.)

Poultry Nutrition—Diets for chicks, poults and breeders, shell quality, vitamin content of eggs.

(Ontario Agricultural College, Animal Nutrition, Poultry; Hospital for Sick Children, Toronto.)

Canning crops—soil, fertilizer and varietal tests, field studies.

(Ontario Agricultural College, Chemistry, Soils, Field Husbandry; Campbell Soup Co.)

Atherosoelerosis in chickens—Cholesterol feeding.

(Ontario Agricultural College, Animal Nutrition and Poultry; University of Western Ontario Medical School.)

RECOMMENDED PROJECTS—AGRICULTURAL RESEARCH—1947-48

Title	Agency	Capital	Operating	Total
Agricultural Products	Ontario Research Foundation	$2,000.00	$18,000.00	$20,000.00

5. CONCLUSION

The members of the Advisory Committee on Agricultural Research wish to express their appreciation of the interest shown in the problem of agricultural research by the Ontario Research Commission and for the opportunity to present this statement.

It is hoped that the Commission will be sufficiently impressed with the character of the programme presented to give full support in every way to its furtherance.

COMMITTEE ON MINES, MINERALS AND METALLURGY RESEARCH

Meetings—

Informal.....Sept. 12th, 1946—Committee Room No. 2, Parliament Bldgs.

Formal.....Nov. 15th, 1946—Committee Room No. 2, Parliament Bldgs.

Committee—

Professor H. S. Armstrong	McMaster University
Professor E. L. Bruce	Queen's University
Professor O. A. Carson	Queen's University
Dr. O. W. Ellis	Ontario Research Foundation
Mr. Chas. Evans	Union Gas Company
Dr. G. Farnham	International Nickel Co.
Dr. D. L. H. Forbes	Teck Hughes Gold Mines
Professor J. E. Hawley	Queen's University
Mr. N. Parkinson	Ontario Mining Association
Professor L. M. Pidgeon	University of Toronto
Professor G. H. Reavely	University of Western Ontario
Dr. H. C. Rickaby	Lands and Forests, Ontario
Mr. R. H. Rimmer	Aluminum Co. of Canada Laboratories
Mr. W. Samuel	Steep Rock Iron Mines
Mr. Geo. Thomson	General Engineering Co. of Canada
Mr. W. B. Timm	Dept. Mines and Resources, Ottawa
Dr. C. Whittemore	Deloro Smelting & Refining Co.
Mr. G. E. Willey	Algoma Steel Co.
Professor C. G. Williams	University of Toronto
Professor J. T. Wilson	University of Toronto
Mr. R. B. Young	Ontario Hydro-Electric
Mr. T. Hardy	Climax Molybdenum Co.

CONTRIBUTION TO DISCUSSION ON MINES, MINERALS AND METALLURGICAL RESEARCH IN ONTARIO

O. W. Ellis, Ontario Research Foundation

Just before the war, in 1938 to be exact, the Department of Engineering and Metallurgy, with a staff, under the speaker's direction, of four graduates and six technicians, was carrying out independent research work along the following lines:

1. Resistance of metals to abrasion—O. W. Ellis and P. E. Cavanagh.
2. Powder Metallurgy—W. R. Jackson.
3. Forgeability of metals—O. W. Ellis and technician.
4. Magnetic Inspection of Metals—F. E. Coombs (1/2 year) and P. E. Cavanagh.
5. Applied elasticity—J. N. Goodier (1/2 year).
6. Effects of manganese and silicon on white cast iron—C. Tasker and technician.

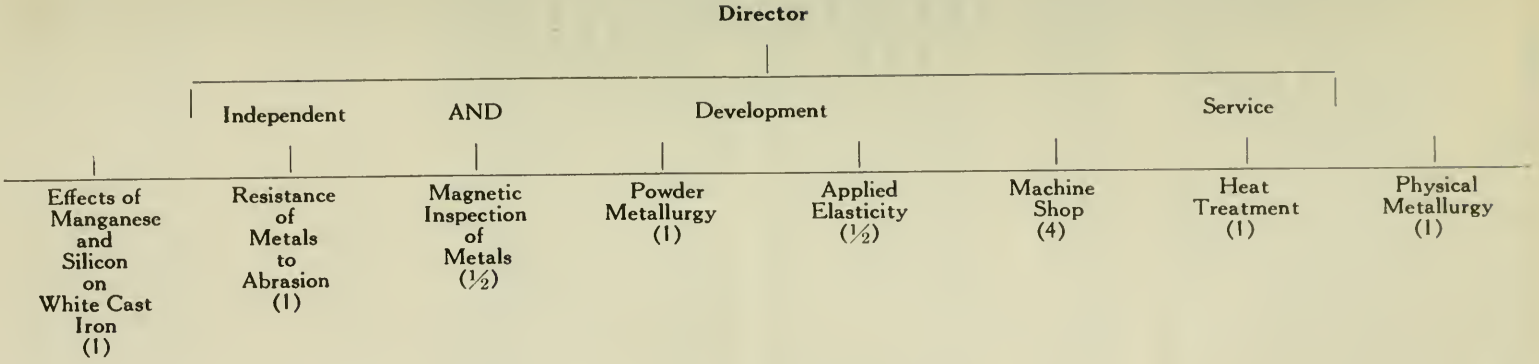
At the same time these graduates and the technicians were available to assist the Director of the Department in the solution of problems of industrial development, that is, problems which involve the application of present knowledge to their solution.

In response to a widespread demand, work on the resistance of metals to abrasion was started at the Foundation shortly after it was created and has continued ever since. There can be no question as to the importance of this work, because any means whereby abrasion of metals in service can be inhibited is of vital importance to the consumer. Conservation is as vital here as it is elsewhere. The present interest of manufacturers in this subject is evidenced by the fact that during the course of the last two or three weeks enquiries have been received from no less than three different sources, one even from Belgium regarding the work of the Foundation in this field. Another of these enquiries raises the possibility of establishing a Fellowship at the Foundation to investigate the wear of grinding balls. The last refers to the problem of abrasion in agricultural machinery. The Foundation is one of the few places in the world where research on this important subject has been consistently pursued. It is to be hoped that work along these lines may be continued.

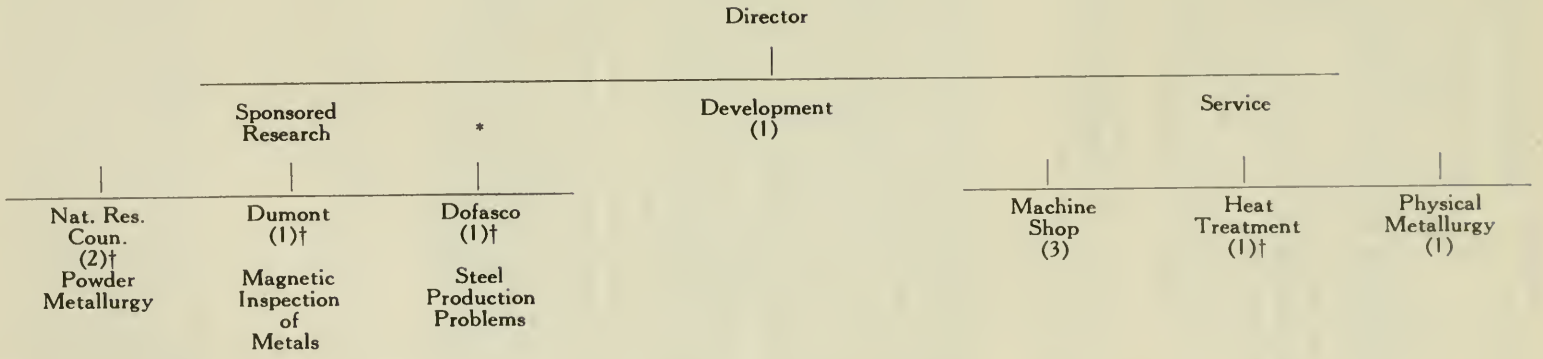
The Foundation is equipped with one of the best powder metallurgy laboratories on the North American continent. Prior to 1941 a number of short term investigations were carried out in this field on behalf of manufacturers in the Province. Concurrently independent work was done on a number of ferrous alloys. At the present time the National Research Council is sponsoring a Fellowship which involves the application of powder metallurgy to its solution. We would like to see independent work in this field revived.

Work on the forgeability of metals was started by the writer while he was on the staff of the University of Toronto and has been continued ever since. The results of this work have proven of value in certain fields of engineering. An equation developed by us and relating the energy required to forge metals and the dimensions of the parts being forged is being employed by a number

1938



1946



*No connection between these two divisions.

Number of men engaged in each division shown in brackets. Where ½ appears in brackets 6 months period only worked.

†Self-supporting.

of engineers working in this field. There are still points of interest which need to be investigated. A technician is needed to assist in this work.

Our work on the magnetic inspection of metals, which was a by-product of our work on the resistance of metals to abrasion, resulted in incalculable savings to industry during the War. Not only so, but this work was the indirect cause of the development of two new types of electrical instruments for the non-destructive testing of metals, namely the Cyclograph and Cable Tester. The Dumont Company of Passaic, N.J., was directly responsible for this development. They have established a Fellowship at the Foundation, the incumbent of which is the young man, Mr. P. E. Cavanagh, who, in 1938, co-operated with the speaker in the investigation of the resistance of metals to abrasion. We are anxious to pursue our investigations in this field, and, in particular, to correlate the electrical and magnetic properties of metals when under stress.

The work of Dr. Goodier in the field of applied elasticity is well known to most of the engineers in this group. Most of them will agree with me that it was a great pity that we lost to the United States a man having the outstanding ability of Dr. Goodier.

Our work on the effects of manganese and silicon on white cast iron was yet another outcome of our work on the resistance of metals to abrasion. Certain of the alloys investigated by us were found to have physical and mechanical properties of considerable interest. Some of these alloys were used on a small scale in a rather special industrial application. A further reason for pushing forward with this work is that our investigations have shown that published information regarding these alloys is far from correct and should be amended in line with further investigation. A technician is needed for this purpose.

At the moment work on these subjects is practically at a standstill. Whereas in 1938, four graduates were employed in independent research and were available to assist the speaker in development work, at the present time only one recent graduate is at hand. It is true that three Fellowships, sponsored by the National Research Council, Dumont, and Dominion Foundries and Steel Company Limited respectively, are operating at the present time, but independent investigation on the resistance of metals to abrasion, the magnetic inspection of metals, powder metallurgy and the effects of manganese and silicon on white cast iron cannot be proceeded with unless further assistance is given the Department. A comparison of the situations in 1938 and 1946 can be gathered by reference to the table on page 117,

CONTRIBUTION TO DISCUSSION ON MINES, MINERALS AND METALLURGY

R. J. Traill, Bureau of Mines, Ottawa

Mr. Parsons has presented a brief general outline of the facilities of the Bureau of Mines Laboratories at Ottawa and its general policy with respect to service to the needs of Canadian Industry.

I am asked to present a statement of the research being done in the Mineral Dressing and Metallurgical Division and to include recommendations for extension of the work.

As outlined by Mr. Parsons this Division comprises three main sections, namely:

1. Mineral Dressing and Extractive Metallurgy.
2. Physical Metallurgy Research.
3. Ceramics and Non-Metallics.

While much of the work coming to the Mineral Dressing Section is of a routine investigation character, there is quite a proportion of problems that entail special study or research investigation. Refractory gold ores and complex base metal ores may be cited as examples wherein methods other than those usually employed have to be investigated and developed.

Recently, we have been investigating the "sintering" of certain Ontario iron ores with the purpose of developing a technique to produce a better sinter.

Certain complex fluorspar deposits have also been receiving attention, the problem being to eliminate co-occurring minerals such as calcite and barite and produce a readily marketable product.

A special investigation in hand at present concerns the radioactive minerals, rapid methods of radiometry being of special importance and attention.

There are, however, quite a number of matters relating to Mineral Dressing that could profitably be the subject of research. such as Roasting sulphide-arsenide gold bearing concentrates, a complete study of the behaviour of metallic minerals in cyanidation, a study of the process of flotation and reagents, the occurrence of gold, chlorine metallurgy, utilization of pyrite for sulphur and iron, etc.

There is much fundamental data yet to be obtained concerning the above problems and this Division has not had sufficient staff in the past to carry out such research and at the same time meet the current demands of industry.

There are also problems in metal refining and in the production of pure metals.

Regarding the Physical Metallurgy Laboratories the activities and facilities of this section are summarized in the attached memoranda. The facilities here outlined are being added to continually with the latest available equipment. It will be seen that these Laboratories can serve industry in many ways. In addition, an effort is being made to carry on a number of research projects.

Some idea of the work being performed may be obtained from the date given in the following pages,

In the Ferrous Section, the Welding Laboratory is investigating welding methods on all types of metals and alloys and co-operating with various organizations in development of new techniques.

In the Ferrous Foundry, research projects involving foundry sand properties are in hand in co-operation with the Steel Castings Institute of Canada. A plan of co-operative research is being arranged with the British Cast Iron Research Association.

The Sand Testing Laboratory is testing sands from various parts of Canada in an effort to find Canadian sands suitable to foundry uses.

In the Precision Casting Laboratory the various techniques have been evaluated for various alloys, especially high melting point alloys.

The Ceramic Laboratories, formerly under the Industrial Minerals Division have recently been attached to the Mineral Dressing and Metallurgy Division.

In addition to the usual industrial service activities these laboratories are conducting special investigations in special refractories, porcelain from Kaolin, whiteware body manufacture, crucible linings, and are starting a study of high temperature phase equilibria in the field of ceramics and refractories.

From this general summary it will be seen that the Mineral Dressing and Metallurgy Laboratories are well equipped with the necessary facilities for research of a character required in the metallurgical industries.

PHYSICAL METALLURGY RESEARCH LABORATORIES

Brief Outline of Activities and Facilities

The activities and services of the Physical Metallurgy Research Laboratories of the Bureau of Mines can be summarized as follows:

1. **Fundamental and Applied Research** in the field of physical metallurgy including studies on physical, mechanical and chemical properties of metals and alloys, their fabrication techniques (melting, alloying, casting, rolling, extrusion, forging, drawing, heat treatment, joining and surface protection), testing methods and proper applications.
2. **Development of Fabricating Methods** of metallic products for special applications or for new alloys.
3. **Testing of Metals and Alloys,** and their products, submitted to the P.M.R.L. for examination of properties, fabricating characteristics and serviceability, or to establish causes of failure in production or service.
4. **Advisory and Information Service** for other Government agencies, Branches of the Armed Services, Industrial Organizations and Individuals on properties of metals and alloys, fabrication and testing methods, and proper applications.
6. **Collecting of Scientific and Technical Data** on metals and alloys, their properties, fabrication and testing methods, and serviceability compiled from publications and information accumulated from experimental work and co-operation with other research organizations and industry.

To attain the above aims the organization and the facilities of the P.M.R.L. are divided into five main Sections comprising the following laboratories, experimental shops and services:

(1) **Ferrous Metals Section:**

Ferrous Experimental Foundry (Sand Casting).
Ferrous Metallography and "Trouble-Shooting".
Ferrous Heat Treatment.
Welding Laboratory.
Sand Testing Laboratory.
Precision ("Lost-Wax") Casting.
Photographic Service.

(2) **Non-Ferrous Metals Section:**

Non-Ferrous Experimental Foundry (Sand, Permanent Mould, Pressure Die, Centrifugal and Billet Casting).
Metal Forming Laboratory (Rolling, Extrusion, Forging, Drawing, etc.).
Non-Ferrous Heat Treatment.
Non-Ferrous Metallography and Radiography.
Non-Ferrous "Trouble-Shooting".

(3) **Mechanical Testing Section:**

Routine Testing.
Fatigue Testing.
High Temperature Alloys Laboratory (Creep).
Low Temperature Testing.
Stress Analysis.
Shot Peening.

(4) **Physical Section:**

Testing of Physical Properties (thermal, electrical, etc.).
X-Ray Diffraction.
Analysis of Gases in Metals.
Powder Metallurgy.
Glass Blowing Shop.
Statistics.

(5) **Chemical Section:**

Corrosion Laboratory.
Surface Protection of Metals.
Pickling Shop (for the Metal Forming Laboratory).
Extractive Metallurgy.

The Analytical and Spectrographic Laboratories are shared with the Mineral Dressing Laboratories. Preparation of test specimens and construction of equipment is carried out by the various workshops of the Maintenance Section of the Bureau of Mines.

Brief descriptions of the activities and equipment of the above listed Sections, as well as some photographs of building and equipment can be furnished if desired.

PHYSICAL METALLURGY RESEARCH LABORATORIES
BUREAU OF MINES

DIVISION OF METALLIC MINERALS

MECHANICAL SECTION

The general functions of the Mechanical Section of the Physical Metallurgy Research Laboratories; the present programme of Research Projects and the equipment are cutlined very briefly in the following notes:

The main activities of the Mechanical-Metallurgical Section may be divided as follows:

(a) Solution of vital problems for industrial organizations, involving fracture investigations, production difficulties, new developments, etc., and the provision of answers to technical questions.

(b) The carrying out of large research projects put forward by Canadian industry and the Industrial Research Organizations or by Government departments.

(c) Research projects initiated by the Physical Metallurgy Research Laboratories Research Committee and influenced by the current and probable future needs of the Canadian industry and Government departments.

(d) Research projects performed in collaboration with the Research Organizations, Institutes, Universities, and Industrial Organizations in Canada, Britain and the U.S.A. and covering the most vital needs of Canadian science and industry.

The major investigations and researches at present in progress in the Mechanical Section of the Physical Metallurgy Research Laboratories are given below:

1. **Research on Optimum Thread Form for Proposed Anglo-American Canadian Screw Thread.**
2. **Research on the Axiality of Loading Using Plain and Spherical Seat Adaptors under Static and Dynamic Direct Loading.**
2. **Research on the Progress of Plastic Deformation of Samples Undergoing the Fatigue Tests.**
4. **Magnetic Analysis of the Progress of Plastic Deformation.**
5. **High Frequency Magnetic and Eddy Current Losses and Their Relation to Internal Stresses and Plastic Deformation in Fatigue.**
6. **Comparative Examination of the Physical Properties of SAE 4340 Steel Heat Treated in Three Different Ways.**
7. **Fatigue Properties of Various Steels.**
8. **Determination of the Effect of Shot Peening on the Fatigue Characteristics of SAE 1045, 3140, 4140 and NE 8640 Steels.**
9. **High Temperature Fatigue Research** (under reversed bending conditions).
10. **High Temperature Fatigue Research** (under direct stress loading).
11. **High Temperature Creep Investigations.**
12. **Analysis of Residual Stresses.**

EQUIPMENT—MECHANICAL SECTION

The Mechanical Section of the Physical Metallurgy Research Laboratories is equipped with the following machines and instruments:

1. **General Mechanical Testing Laboratory:**
   (a) Tensile Compression and Sheer Testing Machines.
   (b) Hardness Testing Machines.
   (c) Impact Testing Machines.
   (d) Ductility Testing Machines.

2. **Stress Analysis Laboratory:**
   (a) Brittle Lacquers.
   (b) Electrical Strain Gauges.
   (c) Extensometers.
   (d) X-Ray Apparatus for Stress Determinations.
   (e) Magnetic Analysis Apparatus.

3. **Fatigue Testing Laboratory:**
   (a) Rotating Beam Type Machines.
   (b) Push-Pull (Direct Stress Loading Machines).
   (c) High-Temperature Fatigue Machines.
   (d) Corrosion Fatigue Testing Machines.
   (e) Aircraft Cable Fatigue Testing Machines.
   (f) Shot Blasting Equipment.

4. **High Temperature Creep Laboratory:**
   (a) High-Temperature Creep Testing Machines.
   (b) High-Temperature Tensile Testing Machines.

CHEMICAL METALLURGY RESEARCH SECTION

Bureau of Mines, Ottawa, Canada

PURPOSE

The Chemical Metallurgy Research Section is responsible for investigating chemical processes which occur in or are important to the field of metallurgy. These processes are:

1. The corrosion of metals and its prevention.
2. Methods of producing corrosion-resistant alloys.
3. Methods of producing corrosion-resistant, abrasion-resistant and decorative coatings for metals.
4. Methods of producing pure metal compounds from ore concentrates of the metals (including the rarer metals).
5. Methods of producing metals (including the rarer metals) from their compounds.
6. Electrolytic methods of producing metal powders.

EQUIPMENT

The following equipment is in use in this laboratory at the present time:

Sources of alternating and direct current for various types of electrolytic work.

Sandblasting equipment.

Paint spray equipment.

2 accelerated indoor atmospheric corrosion cabinets.

Accelerated outdoor atmospheric corrosion cabinet together with freezing cabinet.

2 Accelerated marine atmospheric corrosion cabinets.

Rapid intermittent immersion corrosion equipment.

Slow intermittent immersion equipment.

Total immersion corrosion equipment.

Stress corrosion testing equipment.

Steam cabinet for accelerated corrosion testing.

Water displacement test equipment.

Taber Abrasor for determining wear resistance and shear hardness of coatings.

Aminco-Brenner Magne-Gage for measuring coating thickness.

Solvent vapor degreaser.

Miscellaneous instruments for measuring pH, conductivity, voltage, current, etc.

The following equipment will be installed in the near future:

40 kva high frequency converter and miscellaneous assortment of induction furnaces;

furnaces for heating under vacuum or reduced pressure;

electrolytic hydrogen generator and equipment for purifying and drying the hydrogen.

We also have access to microscopes and other metallographic equipment and to the analytical, spectrographic, mechanical testing, machine shop and other facilities of the Bureau of Mines.

NON-FERROUS METALS SECTION, P.M.R.L.

Brief Outline of Activities and Equipment

The activities of the Non-Ferrous Section, P.M.R.L. are divided as follows:

(A) **Non-Ferrous Experimental Foundry**

1. Melting and Refining.
2. Sand Casting.
3. Permanent Mould Casting.
4. Centrifugal Casting.
5. Pressure Die Casting.
6. Slab and Billet Casting.

7. Magnesium Alloying.
8. Development of Aluminum -Magnesium Alloys.
9. Properties of Magnesium Casting Alloys.

(B) **Heat Treatment of Non-Ferrous Metals**

1. Heat Treatment of Magnesium Casting Alloys.
2. Heat Treatment of Aluminum-Magnesium Alloys.

(C) **Plastic Deformation of Non-Ferrous Metals.**

(D) **Metallography and Radiography.**

The main facilities of the Non-Ferrous Section are listed below. Additional equipment, e.g., recording and controlling apparatus, auxiliary tools, crucibles, patterns, moulds, etc., are omitted.

A. NON-FERROUS EXPERIMENTAL FOUNDRY

1. **Melting Furnaces:**
   (a) Gas fired Holding Furnace for magnesium, aluminum and brass permanent mould and pressure die casting.
   (b) Gas fired magnesium melting furnace, 90 lb. capacity.
   (c) Two gas fired melting furnaces for aluminum and magnesium alloys, capacity 50 lb. Al.
   (d) Two coke fired Pit furnaces for bronzes and brass, capacities for 50 lb. and 150 lb.
   (e) Small gas fired furnace for experimental melting, capacity 10 lb. Al.
   (f) Ajax High-Frequency Vacuum furnace, capacity 50 lb. brass; this furnace can be used for melting and pouring under protective atmospheres.
   (g) Two Ajax High Frequency furnaces, capacity 500 lb. and 50 lb. brass.

   All melting furnaces have accurate temperature control and recording.

2. **Pressure Die Casting Machine** for aluminum, magnesium and brass. Pressures on the metal up to 3k,000 p.s.i. and additional goose-neck attachment for zinc alloys.

3. **Vertical Centrifugal Casting Machine** for moulds up to 30 ft. in diameter and continuously variable speed control 0-1700 R.P.M.

4. Complete **equipment for permanent mould casting** of aluminum and magnesium alloys.

5. Various permanent moulds for **casting of rolling slabs and extrusion billets** from aluminium, magnesium, copper and zinc alloys.

6. **Semi-continuous (D.C.) Casting Machine** for rolling slabs and extrusion billets up to 8′ length will soon be installed.

7. **Sand Preparation Equipment** including a Simpson Sand Mixer 3′ diam. and 1 1/2 cu. ft. capacity, vibrating Screen, Royer jolt-squeeze moulding machine, small Royer sand conditioner, core moulding bench, etc.

8. **Complete Sand Testing equipment** including all routine sand testing A.F.A. apparatus, and special equipment for sand testing at elevated temperatures.

9. **Core Oven,** electrically heated, approximately 16 cu. ft. capcity.

10. **Auxiliary equipment,** e.g., a 3 ton crane, ladles, flasks, etc.

B. NON-FERROUS HEAT TREATMENT

1. **Small Homo-Furnace** (Leeds and Northrup) 12.5″ diameter and 15″ deep, with forced air circulation and Micromax controlling and recording instruments. This furnace is used for solution heat treatment of low zinc containing magnesium alloys and for ageing of all magnesium alloys.

2. **Small Homo-Nitriding Furnace** (Leeds and Northrup), 14″ diameter and 16″ deep, with Micromax controlling and recording instruments. This furnace is used for heat treatment of magnesium alloys under protective atmospheres (mostly CO^2).

3. **Two Walker Vertical Tempering Furnaces** (with forced air circulation) with retorts 13″ diameter and 14″ deep, capable of operating up to 700°C (1300°F). Used for preheating of melting charges and heat treatment of light metals.

4. **Constant Temperature Oven** with forced draft, temperature range up to 260°C (500°F), inside dimensions 37″ x 19″ x 25″. Used for ageing and stress relief treatments.

Other heat treating facilities used for Non-Ferrous metals comprise various heat treating furnaces for steel, small laboratory furnaces and two large furnaces in the Metal Forming Laboratory.

C. METAL FORMING LABORATORY

(At present being erected.)

1. A 18″ x 18″ two or four high reversible **Rolling Mill,** powered by a 300 H.P. Ward Leonard controlled drive, intended for hot and cold rolling of sheet and strips, as well as bars. The mill is equipped with winders and a hot upcoiler for strip, and with indicating and recording instrument of roll pressure.

   The mill was built by Dominion Engineering Limited, Montreal, Canada, from designs prepared by United Engineering and Machine Company of Pittsburgh.

2. **A 750-ton Horizontal Direct Hydraulic Extrusion Press.** with billet containers from 3½″ to 7″ in diameter and 16″ length. The press is equipped with a 150 ton piercer which may be added to the main ram to provide 900 ton capacity.

   This machine was built by Loewy Engineering Company of Canada, Ltd., Montreal.

3. A **25-ton** variable speed chain **Drawing Bench** for 15 ft. long rods and tubes.

This machine was built by Aetna Standard Engineering Company of Youngstown, Ohio, U.S.A.

4. **A 500-lb. Combination Drawbench and Wire Block.**

5. **A 1500-lb. Double Frame Forging Hammer,** arranged for operation by air, having 30″ stroke and 9″ x 15″ die face.

   This machine was built by John Bertram and Son, Ltd., Dundas, Ontario.

6. **A 1200 ton double acting Universal Hydraulic Press** is under consideration for press-forging, sheet forming, powder metallurgy, etc.

7. Two 3′ x 3′ x 16′ car bottom **furnaces** for heating billets and slabs, annealing and solution heat treatment of wrought products; One is an electric furnace with forced air circulation for temperatures up to 650°C (1200°F), and the other is oil fired for temperatures up to 1300°C (2400°F). Both furnaces are provided with very accurate temperature controls and can be used for heat treatment under protective atmospheres.

   These furnaces were built by Peacock Brothers, Ltd., Montreal, to designs of the Electric Resistance Furnace Company, Ltd., Netherby, Queen's Rd., Haybridge, Surrey, England.

8. **Auxiliary equipment** comprises sheet shears, bandsaw, slab and billet scalping equipment, a 5 ton crane, etc.

9. **Pickling shop** with six tanks to handle the products of the Metal Forming Laboratory. The tanks are provided for a variety of solutions.

D. METALLOGRAPHY AND RADIOGRAPHY

1. Zeiss Metallographic Microscope (older type) with complete set of accessories.

2. Bausch and Lomb Metallographic Microscope, Research Model, with complete optical accessories for both bright and dark field illumination and polarized light.

3. Vickers Projection Microscope with complete accessories for bright and dark field illumination and polarized light, also microscopic attachment and accessories for using transmitted light.

4. **Three Table Microscopes** for routine examinations.

5. **Tukon Microhardness Tester,** complete with microscope and mechanical stage (Knoop Hardness).

6. Eberbach Microhardness Attachment (Vickers type indentations).

7. Spencer Bierbaum Microcharacter (microhardness testing of bearing alloys).

8. Complete **Sample Preparation Equipment** including cut-off wheels, mounting press, grinding, polishing and etching facilities.

9. **150 Kvp X-Ray Unit** (Philips Electronic Searchray Model 150) for radiographic examination of light metals (up to 4″ thickness) and steel (up to ½″ thickness).

ACTIVITIES OF THE FUELS DIVISION BUREAU OF MINES, OTTAWA

IN RELATION TO THE FUEL RESOURCES OF THE PROVINCE OF ONTARIO

The fuel resources of Ontario, with which this Brief deals, are Onakawana lignite, peat fuel and moss, and natural gas. The Fuels Division activities reviewed concern tests on investigations conducted during the period 1928 to 1942 and those that merit consideration in the near future. A selected reference list including both published and unpublished reports originating in the Bureau of Mines, Ottawa, the Ontario Research Foundation, the U.S. Bureau of Mines, and elsewhere is given on page 134.

ONAKAWANA LIGNITE

Starting with analyses and small scale burning, carbonization and briquetting tests on outcrop samples submitted in 1928 and 1929, a series of tests were conducted at the Fuel Research Laboratories at Ottawa on carlot samples of the Onakawana lignite from Northern Ontario. These comprised preliminary drying tests in 1930, pulverized fuel tests during 1930 and 1931, tests in a special stoker fired (and hand fired) boiler in 1931, carbonization and briquetting tests in the same year, and special drying tests in connection with a proposed T. & N.O. programme. The results of an intensive investigational programme conducted by the Ontario Research Foundation during 1931 and 1932 are to be found in the annual report for 1933 of the Provincial Department of Mines (6).

Subsequent investigational work (8) was carried out at the Fuel Research Laboratories at Ottawa in 1940 and 1941, comprising drying tests with steam at high pressure and weathering and burning tests on the steam dried lumps. During the same years Fuels Division engineers witnessed burning tests (10) of steam dried lignite and bituminous coals in locomotives and in a stationary boiler of the T. & N.O. Railway.

The results of tests may be summarized as follows:

Classification—Lignite, unconsolidated brown coal.

Analyses—Run-of-mine carlots—Moisture 52%, Ash 7.0%, B.T.I. (as mined) 5,000, and dry basis 10,420.

	47% Moisture (As Received)	15% Moisture (Partially Dried)
Pulverized Fuel Tests		
B.T.U./lb. as fired	5025	9000
Per cent of rated capacity of boiler	80%	150%
Equivalent evaporation per lb. fuel fired	3.2	6.0
Boiler Tests on special pyramid grates		
	(33% Moisture Content)	
B.T.U./lb. as fired	6850	....
Equivalent evaporation per lb. fuel fired	3.7	....
Equivalent evaporation per lb. standard bituminous coal	8.1	....
Domestic Hot-Water Boiler Tests on air dried lumps		(19% Moisture)
Combustion rate; % of rated capacity		53%
B.T.U./lb. as fired		8350
Lignite used to equal 1 ton American anthracite (tons)		1.9

These were the results of tests conducted up to and including 1931 which demonstrated that Onakawana lignite of high moisture content could be pulverized, and burned with an equivalent evaporation of approximately one-third of that of standard bituminous coal, which was raised to two-thirds for 15% moisture content lignite, and that the air dried lumps were serviceable for domestic fuel purposes.

In order to overcome poor weathering and handling properties with serious crumbling and production of fines by exposure to weather, drying by pressure steam as per the Fleissner process, was experimented with (8) to produce more stable lump fuel than obtainable by ordinary air or fuel gas drying. Tests at 200 and 400 pound pressures produced a lump product with 19% and 13% moisture content respectively, the latter with 9750 B.T.U. value having burning properties somewhat similar to Alberta domestic sub-bituminous coal.

Steam dried lignite produced in the experimental drying plant at 100 and 200 pound pressures at North Bay under the auspices of the T. & N.O. Railway Commission were tested (in December 1941 and January 1942) in railway locomotives and also under the T. & N.O. stationary boiler plants. The results of the boiler tests agreed fairly closely with those of former tests at the Fuel Research Laboratories in showing equivalent evaporation per pound of fuel fired values of 3.06 lb. for raw lignite, 4.04 for steam dried lignite (with 35% moisture), 6.68 lb. for mixture one-half raw lignite and one-half Nova Scotia coal, and in comparison with 9.09 lb. for the (Dominion) N.S. bituminous coal alone.

The results of tests in railway locomotives indicated that mixtures of 1¼ parts of steam dried lignite with 1 part of suitable bituminous coal could be used in standard engines hauling tonnage trains with minor structural engine modifications which would allow for operation with bituminous coal alone when desired—the dried lignite analyzing roughly 25% moisture, 7% ash and 8,100 B.T.U.'s.

Carbonizing and Briquetting—Early tests conducted at the Fuel Research Laboratories were confirmed by large scale tests in Germany by the Lurgi process. As summarized by Tasker (6a), carbonizing and briquetting with a pitch binder was technically feasible but the costs were uneconomic in northern Ontario. Satisfactory char briquettes of 12,000 B.T.U. (with 13% ash) were made which would compare favorable with briquettes from Saskatchewan lignite char.

In that report (6 and 6a) briquetting without a binder was concluded to be economically attractive but technically impossible at that time. Briquetting tests (7) at high pressure without a binder conducted in the Komarek-Greaves experimental laboratory in Chicago in 1941 produced remarkably good briquettes (with 8,300 B.T.U. value) from raw dried pulverized lignite. These and the results of high pressure tests on Saskatchewan lignite recently conducted by Prof. Piersol at the University of Illinois and witnessed by a Fuels Division engineer are challenging the former conclusion that briquetting without a binder is technically impossible. Despite the fact that binderless briquetting would require under cover storage for the briquettes, it gives good promise of being both technically and economically possible for the utilization of raw lignite fines normally produced in mining operations, and also the fines produced in the steam drying treatment.

NEW PRESSURIZED COMBUSTION AND CARBONIZATION PROCESSES

The recent application to coal technology of the "Explosion Process" which has been in use for many years in the wood pulp and cereal industries is of particular interest to Onakawana lignite since it offers a means of utilizing low rank (high moisture) coals—being more applicable to fines than to lump coal. This process by which puffed or "shot from guns" cereals are produced consists generally of the charging of the cereal or other raw material into pressure vessels, introduction of low pressure steam, and then their discharge by the rapid release of the pressure.

John I. Yellott* and A. D. Singh** have developed a "coal atomizer" (14) for pulverizing and drying coal employing the explosion process principle which they claim makes possible the drying and pulverizing of lignite as easily as bituminous coal. In the coal atomizer, super heated steam or warm air under pressure meets a stream of crushed coal at the end of a screw conveyor, and the sudden lowering of pressure as the coal passes through a specially designed nozzle causes particle explosion reactions to produce simultaneous drying and pulverizing. The reported lowering of the moisture content of North Dakota lignite from 37% to 4% under a coal atomizer experimental test suggests that it is indeed worthy of testing this application to Ontario and other Canadian lignites.

The Locomotive Development Committee, a separate and distinct project of Bituminous Coal Research Inc., under the directorship of Mr. Yellott has been intensively active since early 1945 in the development of a new coal-fired gas-turbine railway locomotive. The coal atomizer principle mentioned above is employed to continuously deliver dried pulverized coal under pressure to a "combustor" in which what is termed pressurized combustion takes place. The hot flue gases, after the removal (under pressure) of the fly ash serve to drive the gas-turbine for the direct generation of power. In comparison with Diesel locomotive operation costing slightly over 22c. per locomotive mile including cost of fuel and lubricating oil (the latter at 2.7c. per mile) the operation cost of a coal-burning gas-turbine locomotive is estimated at approximately 8c. per mile which is nearly one-third. In addition to no lubricating oil being required the coal-burning turbine requires no water and claims are made that it will be three or four times as efficient as to-day's coal-burning steam locomtive. It is further stated that the battle of the locomotive fuels, i.e., coal versus oil, will be fought on economic grounds and that coal will have an excellent opportunity to win with the gas-turbine. Since any kind of coal including lignite, and particularly the cheaper fines product, can be used, which coupled with the fact that gas turbines can be operated more efficiently in winter than in summer weather, the subject of the utilization of northern Ontario lignite in the raw or partially dried state as locomotive fuel in that part of the country may well be investigated.

The **Fluidization Process** for the partially devolatilization of coal as experimented with by Singh (15) has features applicable to the utilization of Onakawana lignite. This process, which is reported to have been employed in large scale operations involving fluidized gasification of brown coal in Germany, comprises

*Director of Research, Locomotive Development Committee, Bituminous Coal Research, Inc. Baltimore.

**Supervisor, Coal and Gasification Section, Institute of Gas Technology, Chicago.

the reaction of superheated steam on pulverized coal in a suspended fluidized state (i.e., the mixed vapour and solid particles acting as a fluid), to yield the combustible gas similar to water-gas, and a char product with volatile matter content greatly reduced from that in the raw coal feed, and a high yield of primary tar. The finally divided char particles when briquetted would be serviceable for domestic fuel purposes, or it could be utilized for the production of "synthesis gas" for the eventual production of petroleum oil products by the Improved Hydrocarbon Synthesis Process known also as the Improved Fischer-Tropsch Process.

Another process worthy of note here is the gasification process applicable to non-caking sub-bituminous and lignite coals developed by Parry (13) and his associates at the U.S. Bureau of Mines Station at Golden, Colorado. This process now on a small pilot plant scale and which consists of gasifying by the water-gas reaction of coal fed continuously through the annular space between two special metal vertical tubes externally heated is applicable to Okanawana lignite, since it was designed specially for the gasification of non-caking coals. Like the fluidization process it can serve either for complete gasification with gas as a main product or for the production of a char with gas and tar by-products.

PEAT FUEL AND MOSS

Most of the investigational work on peat fuel by the Division of Fuels was conducted prior to, and during the existence of the joint (Dominion and Province of Ontario) Peat Committee 1918-1922, and is recorded in the final report (17) of that Committee, while the peat moss activities have been mostly since 1940.

The story of endeavours to establish a peat fuel industry in Canada as an auxiliary source of fuel supply in the central Ontario and Quebec "acute" area where shortages of domestic supplies of fuel have periodically occurred, is in many respects similar to that of lignite from northern Ontario. The problem has been and still is how to mine and reduce the moisture content in order that the dried fuel can compete with coals, cokes, and other solid fuels. The fundamental difference between raw peat and lignite, as removed from the ground with 90 and 55% water content respectively, is that peat, as it dries, especially after pulping, forms a coherent mass whereas lignite slacks and becomes quite friable with loss of moisture by crying. However, it is to be observed that irrespective of their physical properties, peat and lignite with the same moisture contents have closely approaching calorific values, and for combustion, carbonization, liquefaction, and total gasification treatment they have much the same characteristics—with peat having lower sulphur content and appreciably higher tar oil yields. Reference (17) contains the results of air drying briquetting, and carbonizing investigations, and in references (2), (3) and (5) are to be found respectively the results of pulverized fuel steaming, domestic fuel, and hydrogenation tests on air dried peat from Alfred, Ontario.

Peat Moss. (22) The production of peat moss which has grown into a sizeable industry from 17,000 tons in 1940 to 63,000 tons in 1945 (with a value of $1,500,000) is mostly all exported to the United States. It is used for stable bedding and poultry litter, for soil conditioning and a filler for commercial fertilizers, and as an insulating and packing material. In 1944 there were six companies in Ontario which produced 9800 tons of moss—the two largest producers being Erie Peat Co., Welland and Canadian Industries Limited, Erieau, near Rondeau Bay on Lake Erie.

NATURAL GAS

Ontario's natural gas resources, as is well known, are located in the south-western corner of the Province with Sarnia and the Niagara Peninsula as the western and eastern boundaries. As indicated in reference (24) containing the analyses of 198 samples of natural gas from 19 different fields, the higher hydrogen content, i.e., other than methane, ranges roughly from 10 to 20% with heating values varying from slightly below 1,000 to over 1,100 B.T.U. per cu. ft. During the war the supply of gas had to be augmented in certain areas by manufactured gas from coal to meet special war plant demands in addition to city franchise requirements. While natural gas in Texas and other parts of the United States, and Turner Valley (Alta.), surplus gas is a favourite source of synthetic liquid gasoline and other petroleum products by the modified Fischer-Tropsch process, the Ontario gas although a potential source, is generally considered not available for this purpose on account of its relatively high monetary value for city distribution.

FUELS DIVISION INVESTIGATIONS

The investigational and research projects, comprising the programme of the Bureau of Mines, Fuels Division for the immediate future, are listed below in relation to the Province of Ontario's different fuel resources, viz., Lignite, Coal, Peat Fuel and Moss.

A. Laboratory (physical and chemical) testing of coals, briquettes, coke, peat, etc.

B. Physical and Chemical Survey of Canadian coals supplementing and enlarging that conducted in prewar and war periods.

C. Coal sizing, cleaning, and briquetting investigations, and review of coal preparation and beneficiation methods employed in the United States and other countries. These include briquetting of fines in the raw state from non-caking sub-bituminous lignite coals.

D. Survey of Canada's (exportable) peat moss resources.

E. Periodic (news letter) publications reviewing coal technology developments in foreign countries and their application to Canadian fuel problems.

F. Mechanical coal stoker operation investigation and tests.

G. Carbonization and other treatment of coals in the powdered form by the new fluidization process for the cheaper production of coke and char than obtainable by present commercial processes.

H. Pressurized (gas turbine) combustion of powdered coal in stationary and railway locomotive power plants.

I. Hydrogenation investigations on Canadian coals, heavy oils and bitumen at pressures materially higher than formerly investigated at Fuel Research Laboratories.

Natural Gas and Crude Oil

J. Natural Gas—A survey of resources in Western Canada, and collection and analyses of samples from Ontario.

K. Analysis survey of motor gasoline marketed in Canada.

L. Petroleum Oils—Collection and evaluation of Canadian crude oils with particular attention to that from the Lloydminster (Sask.) and adjoining Vermillion (Alta.) fields.

M. Investigation of the amenability of Canadian natural gas and of the various kinds of coals as a source of "synthesis gas" by the new fluidization treatment as feed stock for the production of petroleum oil products and basic chemicals by the modified Fischer-Tropsch (indirect hydrogenation) process.

SELECTED LIST OF REFERENCES

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(2) "Comparative Pulverized Fuel Boiler Tests on British Columbia and Alberta Coals and on Ontario Lignite" by C. E. Baltzer and E. S. Malloch, Bureau of Mines No. 790—1938.

(3) "Boiler Tests on Coals and Other Solid Fuels" (Reprint of Sections I and II, Part 1, Investigations of Fuels and Fuel Testing, 1930 and 1941, pp. 17-35), Mines Branch No. 725-3—1933 (Onakawana Lignite, pp. 26-35).

(4) "Comparative Tests of Various Fuels when Burned in a Domestic Hot-Water Boiler" by C. E. Baltzer and E. S. Malloch, Bureau of Mines No. 802—1940 (Including tests on Onakawana Lump Coal).

(5) "Tests on the Liquefaction of Canadian Coals by Hydrogenation" by T. E. Warren and K. W. Bowles, Bureau of Mines No. 798—1940 (Coal No. 10 Onakawana Lignite).

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(7) "Preliminary Tests on the Binderless Briquetting of Northern Ontario Lignite by means of the Komarek-Greaves Process" by E. Swartzman, Fuel Research Laboratories, C.S.M. No. 6, June 1941.

(8) "Investigation on the Drying of Northern Ontario Lignite with Steam at High Pressure" by T. E. Warren, K. W. Bowles, W. Gerrie, and E. Swartzman, Fuel Research Laboratories, Bureau of Mines, 1941.

(9) "Report on the Burning Characteristics of Semi-Commercially Steam Dried Ontario Lignite" by E. Swartzman, Fuel Research Laboratories, R.I.C.S.—173—February 1942.

(10) "Burning of Mixtures of Steam Dried Onakawana Lignite and Bituminous Coals in Locomotives and in a Stationary Boiler of the Temiskaming and Northern Ontario Railway in 1941—1942" by R. L. Sutherland.

(11) "The Onakawana Lignite Deposit Report of the Fuel Commission of Ontario"—March 15th, 1944.

(12) "Technical and Economic Study of Drying Lignite and Sub-bituminous Coal by the Fleissner Process" by L. C. Harrington, V. F. Parry, and Arthur Koth, U.S. Bureau of Mines Technical Paper 633—1942.

(13) "Gasification of Lignite and Sub-bituminous Coal Progress Report for 1944", U.S. Bureau of Mines, R.I. 3901—June, 1946.

(14) "The Coal Atomizer—A New Method of Pulverizing and Drying Coal" by J. I. Yellott and A. D. Singh (Reprinted from Power Plant Engineering, December, 1945).

(15) "Partial Devolatilization of Coal by the Fluidization Process" by A. D. Singh (Reprint of paper presented American Gas Association, Technical Section, Joint Production & Chemical Committee Conference, Hotel Pennsylvania, New York, June 3-4-5, 1946.

(16) Coal-Burning Gas Turbines for railway locomotive and stationary power plant purposes—See Reports of Locomotive Development Committee, "Bituminous Coal Research", commencing Volume 3, No. 1, January—March 1945, also Progress Reports of Locomotive Development Committee (No. 3, April 30th, 1946).

Reference re Peat Fuel and Moss

(17) "Final Report of the Peat Committee appointed jointly by the Governments of the Dominion of Canada and the Province of Ontario," by B. F. Haanel, Mines Branch No. 641—1925.

(18) "Facts about Peat", by B. F. Haanel, Mines Branch No. 614—1924.

(19) "The Canadian Mineral Industry in 1944", Bureau of Mines No. 185—See similar Annual Reports for previous years and also for 1945 now in the press.

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(21) "Peat Moss Deposits in Canada", by H. A. Leverin, Bureau of Mines Memorandum Series No. 80—1941 and No. 83—1943.

(22) "The Peat Moss Industry in Canada", by A. A. Swinnerton, Memorandum Series No. 90—1946.

References re Natural Gas

(23) "Analyses of Samples of Natural Gas from Ontario in 1932 and 1933", by P. V. Rosewarne and R. J. Offord, Mines Branch Memorandum Series No. 63—July 1934.

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THE COMMITTEE ON EDUCATION AND RESEARCH GEOLOGY DIVISION

CANADIAN INSTITUTE OF MINING AND METALLURGY

Professor J. E. Hawley, Chairman

In April, 1946 the Geology Division of the Canadian Institute of Mining and Metallurgy set up a committee on Education and Research to enquire into the ways and means of improving geologic education and training throughout Canada and of promoting geologic research in all its many branches.

A committee consisting of representatives of all Canadian universities, departments of mines, Federal and Provincial, and of the mining industry has been named.

With respect to geologic research the committee has recognized that neither in Canada as a whole, nor in individual provinces is there any central organization engaged solely in studying, correlating and promoting geologic research.

To partially fill this lack, two projects have been undertaken:

1. To assemble information on all available instruments and equipment of the types needed for geologic research of a laboratory type, including chemical laboratories, microscopes, polished section apparatus, spectroscopes, and X-ray diffraction apparatus.
2. To canvas all geologists and determine from them—
   (a) Research projects at present being studied, and
   (b) Research problems on which they would like to see work done by others, and for which they themselves have neither the time nor equipment available.

When this information is at hand, it is planned to report the findings to the Institute and make public a list of projects which may be recommended. It is hoped that the actual undertaking of at least some of the projects will be carried out both by officers of various Departments of Mines and by professors and graduate students in universities.

Already many suggestions have been made, including some pertaining to problems in Ontario.

RESEARCH PROGRAMME—DEPARTMENT OF MINERALOGY, QUEEN'S UNIVERSITY, 1946

Professor J. E. Hawley

1. The Synthesis of Certain Minerals

In the belief that a better understanding of the way in which minerals are formed in nature will aid eventually in the exploration for new mineral deposits, experimental work involving the synthesis of several groups of minerals is being pursued in our laboratories.

A considerable amount has already been done on the minerals of the Iron-Nickel-Sulphur group (such as occur at Sudbury) and it is proposed to continue this, enlarging the investigation to include a fourth variable, copper.

Two other groups at present being studied include minerals of the lead-antimony-sulphur group and rare copper and silver selenides.

Investigations of this type include studies of melts, and of precipitates from both acid and alkaline solutions heated in steel bombs. Identification is made positive by X-ray studies of the products formed.

2. The Atomic Structure of Crystalline Substances

Under the direction of Dr. L. G. Berry, investigations are being carried on to determine the structural crystallography of many minerals by means of X-rays, particularly of those species not hitherto studied in this manner. The results will form a contribution to Volume II of the new Dana's System of Mineralogy in course of preparation.

Though chiefly of scientific interest, this affords training to graduate students in a highly specialized technique which is essential for the thorough knowledge and final identification of all crystalline substances, including not only minerals but also all metals and their alloys, and all crystalline chemical compounds.

3. Joint Research Project on Ontario Fieldspar

An investigation of the possibility of separating feldspar from quartz and other minerals with which it is intergrown in many deposits in Eastern Ontario was initiated in 1944 by the Department of Mineralogy with the co-operation of Prof. T. V. Lord, Department of Metallurgy at Queen's University. Flotation and other methods are in use in this respect in other countries, notably in the United States and Germany.

Heretofore production of Canadian feldspar has been from coarse grained, pegmatitic deposits by quarrying operations requiring considerable hand sorting. From these operations recovery has probably been less than 50%. In addition it is known that some such deposits pass vertically downward into finer grained intergrown quartz and feldspar, separation of which is only possible by flotation methods.

Initial experiments have shown that on suitable fresh material a commercial separation of these minerals should be possible.

As Dr. M. L. Keith in the past two summers has been investigating the minerals of Eastern Ontario for the Ontario Department of Mines and has

located other feldspar bearing rocks (syenites) from which it may be recovered by flotation, it is suggested that this project be continued by both him and Professor T. V. Lord and that funds be provided for mill tests to be run on such samples as may be considered promising.

The Qualitative Spectrographic Determination of Rare Elements such as and Including Indium, Gallium, Germanium, Thallium, Hafnium and Rhenium and others in Ontario Minerals.

Research recommended to the Ontario Research Commission

Purpose—The purpose of such a study is twofold:

1. To determine what, if any, minerals in Ontario carry significant amounts of any of these rare metals, some of which have highly desirable properties. Some such as Indium are now being used. The availability of others will determine in part their future utilization. When found, more detailed quantitative methods of analysis may be used on available material.
2. To study known ore deposits of various types by this method in order to determine any genetic relation which may exist between ores and igneous rocks associated with them. This is based on the premise that igneous rocks from which ores have arisen will show spectrographically a similar range and number of rare elements as the ore deposits themselves. Such studies should aid materially in further exploration for ore deposits.

Scope and Duration of Investigations

Both spectroscopic studies of the above types might be carried on in one laboratory or in different laboratories.

They will require several years for their completion.

Initial investigations may be commenced on specimens already available in various Ontario Museums and on material which may be supplied by officers of the Ontario Department of Mines. For the second study noted, and later for the first, special collections will need to be made in the field by those supervising the work.

Equipment Available and Needed

Spectroscopic equipment for investigations of the above types are not believed available at present in Ontario for the steady use they would receive in this work. Instruments of this type are in use at the Mines Branch, Department of Mines and Resources, Ottawa, in the Physics Department, University of Toronto. A Hilger E316 Spectroscope is available in the Geology Department at Queen's University, but requires modernizing. Modern spectroscopic equipment suitable for this work will cost approximately $10,000.00.

Personnel

A full-time technician, who might be trained in this type of routine analytical work would need to be employed at an estimated salary of $1,800.00 per annum.

Supervision of the work may be referred either to the Ontario Department of Mines or to various mineralogists or geologists in Ontario universities, but in either case a well-integrated programme of research along these lines should be drawn up. Many individual problems may be assigned to graduate students where equipment is made available.

GEOPHYSICS RESEARCH

Professor J. T. Wilson, Department of Physics,
University of Toronto

Geophysics at University of Toronto

Due to the work of Professor L. Gilchrist and his associates of the past 15 years, geophysics has been well established at the University of Toronto. The work is included in the Department of Physics but is closely correlated with that in the Departments of Geological Sciences and Mining Engineering. The co-operation of the Ontario Department of Mines and of several mining and geophysical companies has been of great assistance in providing equipment, scholarships and research problems. There is a separate building for geophysics with a considerable quantity of up-to-date equipment, if not all that might be desired. The staff of the three professors have time for some research and the 30 graduate and 4th year students that took courses last year represent the chief supply in Canada of men trained in geophysics.

Geophysical Research

Cases have been mentioned where geophysical methods were of little use. We need to know more of the limitations of geophysics but it is a young science, and what is remarkable is not the failures but the number of applications that have been found for it and the great use it has been to the oil industry for the past twenty years and the increasing use it is becoming to the mining industry. Only more practice and research will increase the uses and reduce and define the limitations. After all, geology has a useful life of more than a century, but it has been recognized as useful to mining for only a fraction of that time.

Research is of at least two kinds, the search for more knowledge by using existing methods and the search for new and more powerful methods. Physics has made great progress because it has discovered and used a series of new and powerful methods or tools such as electricity, electronics, atomic research. Geology, which is a harder subject to observe and deal with, still chiefly has to depend upon the original method by which a man walks over the ground with a hammer and looks at the outcrops. Geology is an intractable subject and no one can suggest any way of dispensing with this primitive method, by which Dr. G. Hanson has calculated that it will take another four centuries at the present rate to complete a detailed geological map of Canada. Certain aids can be used in the search for minerals such as the use of air photographs and the application of several geophysical methods. Research is needed to develop these.

Pre-Cambrian Research

A better knowledge is needed of the pre-Cambrian Shield and especially of its structure which has partly controlled ore deposition. It is after all probably the largest and richest arc of basement rocks in the world. One might think then that in Canada one should find the greatest knowledge of these rocks, but it is not so. The area is so large that it is far from well mapped; it is so rich that more attention has been paid to developing mines found by prospectors than to discovering the true nature of the shield, which understanding might lead to the discovery of hidden ore deposits. At present the smaller and less rich pre-Cambrian areas of Scotland, Finland and United States are better

mapped and understood. These are not facts of which to be ashamed, since they represent a stage in the development of a young country, but the opportunity should be seized and work begun toward the day when a wider and fuller knowledge of the pre-Cambrian can be obtained, and that knowledge can be used economically. Geophysical methods and air photographs can in the meanwhile help to elucidate pre-Cambrian structure.

Airborne Magnetometer

Of recent developments in geophysics the most striking is the conversion of the magnetic airborne detector (M.A.D.) developed for locating submarines to a continuously recording airborne magnetometer for geological purposes. This instrument, which has been perfected as a result of two years' work by the U.S. Geological Survey, the Bell Telephone Laboratories and the U.S. Naval Ordnance Laboratories, is now capable of giving an accurate record of the vertical intensity of the earth's magnetic field at any height and to a sensitivity of one gramme unit. At the same time a radar altimeter and vertical aerial camera record continuously the position of the plane in three dimensions. One of these equipments was demonstrated in Ottawa by its American crew. Three other M.A.D. units have been loaned to the N.R.C. and after modification should be ready for use. It would seem to be an opportunity for research to procure one of these equipments and try it in Ontario.

The speed obtained by these detectors is a vast increase over previous methods. When the plane flies at 150 m.p.h. an average coverage, deducting time for turns and checks, of 100 miles of magnetic profile can be made in one hour. By present ground methods one instrument can only occupy a very few stations a few hundred feet apart in one hour. With lines 1/4 mile apart the new equipment can obtain a contour anomaly map of a 100 square mile township in 4 hours flying time plus a greatly longer time for plotting results. This is a remarkable contrast to the slow compilation of hundreds of commercial surveys that the Geological Survey in co-operation with the N.R.C. Associate Committee on Geophysics is at present undertaking.

Rock-burst and Seismic Research

Another research field in geophysics in Ontario is afforded by the rock-bursts occasionally occurring in certain mines. Although some work has been done, the problem of using seismic equipment to listen for the preliminary noises or microseisims and thus indicate which areas are under great stress and likely to fail by rock-bursts has not been successfully solved. Along with continuing work on this problem there is another of fundamental importance that can be tackled. Each rock-burst is a small earthquake and releases energy waves that penetrate deeply into the earth and return to the surface where they can be detected hundreds of miles away. To understand the structure of the pre-Cambrian shield and the earth's crust deep enough data from geology even in mines cannot be obtained and must come from indirect methods. It seems fundamental to a study of structure and origin of ore that there should be more than a two-dimensional view of the surface of the earth. Seismic studies of rock-burst afford an unusually good opportunity to make such studies for the nature of the whole crust.

In this new science new tools and methods of tackling earth problems are being found. By geophysics the developments in physics to the study of the intractable earth can be made and thus aid the slow method of field geology, but it is a new subject and needs much research in its development.

Aerial Photographs and Their Study

Aerial photographs have now been made of much of Ontario and several million have been made of parts of Canada. Few field geologists will work without them if they can be obtained. Nevertheless the study of them is a specialized job and little literature exists on interpretation. What there is does not often apply to the glaciated and pre-Cambrian areas. During the war it was found useful to give specialist courses on the subject of interpreting aerial photographs for such purposes as finding guns, defences, troops and even of measuring the depth of water over beaches. Courses are needed in use of aerial photographs in geology and we certainly need a collection or list of aerial photographs that illustrate typical conditions in Canadian geology and a text to explain their use is also required.

Radar Location of Photographic Planes

During the war radar techniques called Gee and Shoran were developed by which planes could accurately locate their position. Development is now proceeding at Ottawa towards using such methods for recording the exact position in space of a photographic plane each time it takes an air picture. This may speed plotting, increase accuracy of maps and enable planes to take lines of pictures without gaps and with the minimum of overlap. So large a user of aerial photographs as Ontario could perhaps join in this development research.

Uniformity of Geological Maps

This Commission might set up a sub-committee or take action tc make geological maps in Canada more uniform. From province to province or even working in one region the many different scales and conventions used on geological maps are noticed. If these could be reduced and made uniform it would help prospectors and students alike. There could well be a convention as to scales to be used. Of 63 Canadian geological maps recently examined 29 were on 1-inch to 1 mile scale, but the other 34 were on 16 different scales from 100 feet to 1-inch to 20 miles to 1-inch. Admittedly several scales are necessary, but not nearly as many as are used. Again different provinces are issuing provincial maps on scales of 8, 12, 16 and 20 miles to one inch, so that these maps cannot be directly compared.

The shape and size of maps differs also. Quebec often issues maps of geologically interesting blocks, Ontario of townships and Ottawa on a latitude and longitude grid. There is much to be said for each choice but the consistent use of any one would be better than the present diversity.

The colours used for the same formations vary from map to map; perhaps the U.S. method of printing patterns as well as colours is too expensive and there are not enough colours for formations. It would certainly seem possible to arrive at standard conventions for symbols such as faults, shear zones, etc. The costs of printing maps enters into these matters and perhaps complete uniformity can not be reached, but it does seem that considerable simplification could be agreed to if the matter were considered.

Mathematical Research in Geology

When a sufficiently large number of allied observations have been made mathematical methods can sometimes be applied to reduce the many readings to simple laws. In few cases in field geology can enough allied observations be

assembled of sufficient precision to make this approach useful. On the other hand, another use of mathematics is to make certain assumptions which it is agreed are reasonable and from them to show by mathematical methods that more complex and less expected results must follow if the assumptions are true. In a recent book, "The Dynamics of Faulting," Dr. E. M. Anderson of the Scottish Geological Survey has used the second method with remarkable success. He makes reasonable explanations of how the three classes of faulting can arise and what their properties and associations are. He shows why normal faults may be expected to have varying strikes but uniform dips, whereas tear faults have uniform strikes but variable dips, why intrusions are more likely to accompany normal faulting than thrusts, how in the case of tear faults, if the vertical movements are known, the direction of probable horizontal movements can be predicted.

As the collection of accurate facts known about geology accumulates, more opportunities for application of mathematics will arise. Even when mathematics cannot give a complete answer it can often show that some answers are improbable. There is a need to train students in mathematics and physics, since few field geologists once started on their career can find time to discipline themselves to the study of mathematics, but progress in other sciences has been made by more precision and use of mathematics, so presumably progress in geology will follow the same direction.

THE PROBLEM OF THE CORROSION OF WIRE ROPE

O. W. Ellis, Ontario Research Foundation

There are a sufficient number of variables involved in this problem to make it somewhat difficult. On this account it is proposed that any investigation start with the wire forming the rope, which means that, except that the origin of the wire (type of steel, mill practice, etc.) will generally be known—but that only in general terms, the following variables will be studied and, where possible, controlled.

1. Chemical analysis of **wire**—
   (a) Usual elements.
   (b) Unusual elements.
   (c) non-metallic inclusions.
2. Mechanical properties of **wire**—
   (a) Tensile properties.
   (b) Fatigue properties.
   (c) Hardness distribution.
   (d) Uniformity of properties along wire length.
3. Structure of **wire**—
   (a) Microstructure.
   (b) X-ray structure.
4. **Rope** design and **rope** making practice—
   (a) What effect has the juxtaposition in a rope of wires varying more or less widely in mechanical properties upon its susceptibility to corrosion? Rarely are ropes manufactured of wire emanating from one lot of steel only. Hence, even in ropes made of wires all of one diameter, it could be assumed that differences in potential within a wire might exist in corrosive situations. Where rope design calls for wires of different diameters, as in mine cable, differences in potential due to differences in properties of adjacent wires are almost certain to exist in corrosive situations and might, therefore, be of some importance in speeding corrosion.
   (b) What uniformity of properties can be expected of wire ropes? The application of magnetic inspection (non-destructive) to rope as it issues from the rope machines might be considered in this connection. It is not impossible that variations in the properties along the lengths of wires forming a rope may be completely neutralized when these wires are formed into the rope. This problem might be amenable to statistical investigation.
   (c) What is the role of the lubricant embodied in the core of the rope? What lubricants are presently being used and what new lubricants are available? How can the effectiveness of such lubricants be increased? What are the best core materials available?

   In this connection it should be observed that Imperial Oil Limited are prepared to collaborate with Ontario Research Foundation in an attempt to solve this phase of the problem.

(d) Would the galvanizing of wire be effective in promoting the resistance of ropes to corrosion? How would galvanizing affect the properties of ropes?

(e) What useful information can be obtained by tests on small ropes in such a test hoist as is already in use at the Foundation? It may be observed that a new and safer test hoist is being designed.

In partial reply to these questions it can be pointed out that—

(1) Ropes as small as $\frac{3}{8}''$ diameter and geometrically similar to ropes such as are used as mine cables can be produced for test by rope manufacturers.

(2) That the combined effects of tensile, bending (stresses due to the passage of rope over the drum) and torsional stresses upon the endurance of $\frac{1}{4}''$ diameter ropes are brought out in a matter of about ten days with the present equipment. Torsional stresses can be largely eliminated from test ropes by the use of swivels and the effects of tensile and bending stresses alone investigated.

(3) That the effects of the abuse of wire ropes (lack of lubrication, kinking' overstressing, etc.) can be readily investigated in such a test hoist.

(4) That local and general changes in the magnetic and other physical properties of small ropes can be readily investigated in such a test hoist.

(5) That the effects of controlled corrosive conditions can be readily investigated in such a test hoist and that local and general changes due to such conditions can be followed by means of non-destructive magnetic testing equipment.

(6) That the effectiveness of deterrents to rope corrosion when rope is tested under controlled corrosive conditions can be investigated in such a test hoist.

There are, of course, other factors which need to be taken into account in any investigation of this problem. However, a sufficient number of these factors and probably the most important, have already been referred to. Their investigation will involve considerable time and effort. It seems unnecessary, therefore, to deal with factors of less importance than those already dealt with.

THE PROBLEM OF THE PRODUCTION OF SPONGE IRON IN ONTARIO

O. W. Ellis, Ontario Research Foundation

At the outset it should be made clear that the problem confronting Ontario is not one of **electric smelting of iron,** which it is understood to be the production of pig iron employing solid fuel as reducing agents and using electric power, but is one of production of **sponge iron.** Such sponge iron would serve as a substitute for "foreign" scrap. The magnitude of the scrap problem is shown by the fact that, at the present time, one Ontario steel company requires between 650 and 750 tons of "foreign" scrap every 24 hours. It is most difficult to find sources of such scrap and a sponge iron plant designed to supply all, or even part, of this scrap would ease the situation considerably. The question resolves itself into an economic one—to supply from 650-750 tons of sponge iron every 24 hours using, for example, pre-heated hydrogen as the reducer, would involve the production of something in the neighbourhood of 15,000,000 cubic feet of hydrogen every 24 hours, i.e., assuming that one was desrious of becoming **entirely** independent of solid fuel.

The production of sponge iron using pre-heated hydrogen—an all-electric process—as the reducer represents one extreme of the problem. The production of sponge iron using solid reducer and gas obtained by the gasification of solid carbonaceous fuel—incidental electricity only—represents the other extreme of the problem. The latter extreme it is not the purpose for discussion here. What it is intended to do is to present some information regarding the production of sponge iron using (a) highly beneficiated (95% iron oxide minimum) ores as the source of the iron and (b) electricity both as the source of heat and as the indirect means of providing a gaseous reducing agent, viz., hydrogen. The problem of producing sponge iron of a degree of purity suitable for its use in the manufacture of steel either in the electric furnace or the open hearth is, then, a twofold problem—

1. Means have to be found for beneficiating the ore, so that the material fed to the reducing furnace shall contain not more than a few, at most say five per cent of gangue, since practically all the gangue will find its way into the sponge iron and will lessen its value to the steel manufacturer. Not more than about 5% (many steel manufacturers might consider this figure too high and would also insist on a maximum of 1½% silica) of gangue is the ideal which should be aimed at, because the cost of slagging off the gangue in a steel-making furnace becomes prohibitive if the gangue is in excess of this figure.

A study must, therefore, be made of means of beneficiating our Ontario ores and of the economics of beneficiation and concentration to 95+ per cent of iron oxide. This part of the problem could best be studied by the Bureau of Mines at Ottawa, who are presently equipped to undertake much of the work involved.

2. While economic means are being investigated to beneficiate various ores so as to provide a 95+ per cent iron oxide for reduction, a study of the low temperature reduction of beneficiated ores should be undertaken.

Reduction of the beneficiated ore can be effected by means of solid or gaseous reducers. Reduction can be carried out in—

1. Rotating kilns.
2. Hearth roasters.
3. By-product ovens.
4. Shafts.

The reduction of finely divided concentrates can be carried out in furnaces of the first three types, but finely divided concentrates must be briquetted and, if necessary, sintered to make them acceptable for treatment in shaft furnaces, in which the reducing gases must have free passage through the shaft. Hence the costs of briquetting and sintering always have to be taken into account when the economics of reduction in shaft furnaces are being studied.

The reduction of finely divided concentrates is fraught with some difficulties.

In the first place, if gangue, even though present in small amounts, is self-fluxing and fuses at temperatures below that most suitable for reduction of the oxide, agglomeration of the concentrates will occur and free access of the reducing gases to the oxide will be prevented. This will be the case whether gaseous or solid reducers are employed.

In the second place, particles of reduced iron tend to weld at temperatures usual in low temperature reduction. Welding is facilitated by pressure, hence great care has to be taken to avoid the agglomeration due to welding under presure of the reduced iron particles. Agglomeration may lead, on the one hand, to imperfect reduction, and, on the other hand, to blockage of the furnace due to balling-up of the reduced iron.

The **Rotating Kiln** is "far from ideal as a means of contacting active reducing gases (not produced in the charge itself) with granular ore particles. This is particularly true when the product is sticky, as are reduced pyrite cinders. The fundamental limitations of such reduction to the surface layer of the ore bed in the kiln and the probable inability to treat fines in a rotating kiln, while surely not entirely insolvable technologic problems, militate against a facile demonstration of the economic justification of the process and will probably, even in the face of possible modifications of the kiln design and practice, always constitute an unwarrantable spread between the fuel cost, which has been amply demonstrated, and the final cost of production." (See G. Maier, Sponge Iron Experiments at Mococo, U.S. Department of the Interior, Bureau of Mines Bulletin 396, Washington, 1936.) It might be added that in all experiments so far conducted with rotating kilns thermal efficiencies appear to have been sacrificed in favour of simplicity of design and rapid output. Little is likely to be gained by further investigations involving the use of equipment of this type.

The **Hearth Roaster** has been applied to the reduction of iron oxide by a number of investigators.

For example, a half-hearted attempt was made in 1912 at the New Cornelia Copper Co., Ajo, Arizona, to prepare sponge iron from calcine obtained by roasting pyrite in a Wedge double-junction furnace. This furnace delivered hot calcine directly to the reducing zone; the three upper hearths were of the ordinary type for roasting sulphide ores and the three lower ones were muffle hearths heated with oil from outside fire-boxes. The experiment failed because the temperature of the reducing zone was too low (500-700°C) and could not be increased without warping or burning out the muffle.

A six-hearth MoDcugall roasting kiln was at one time tried out for the same purpose at Anaconda, Montana, but without success.

In both the above experiments the temperature could not be raised to the point where the ore was reduced to metal without permanently damaging the furnace. In view of the fact that it was furnace design rather than anything else which seemed to cause the failure in these and other earlier experiments it is not altogether surprising that Republic Steel Corporation were willing to install in their new low temperature reduction plant a furnace of the hearth roaster type. "The proposed plant will use the Brassert-Cape low-temperature reduction process and is to have a production of 100 tons of sponge per 24-hour day. The ore to be used will be fine magnetite concentrates produced from Republic's low grade magnetite iron ore mines in New York state. The ore will analyze, on a dry basis, about 68.5% iron (or 94.5% iron oxide in the form of magnetite) and 5.5% gangue material, of which about one-half will be silica. The phosphorus and sulphur contents will both be low. The fuel will be coke oven gas from Republic's new coke oven plant now starting operations at Warren. The gas will contain about 56% hydrogen, will be free from tar products and will be relatively low in sulphur content.

The principal items of plant equipment include a Herreshoff roasting furnace, gas handling equipment and briquetting equipment. The Herreshoff furnace, in which the reduction of the ore takes place, is a multiple-hearth type having twelve hearths twenty feet in diameter. The gas handling equipment includes two desulphurizing units in which the incoming coke oven gas will be further desulphurized to minimize the contamination of the sponge iron product with sulphur; a heat exchanger, in which the spent furnace gases will contribute part of their sensible heat to the incoming gas; a pre-heater, in which the incoming gas will be further heated to the desired temperature; a gas washer, which will clean the spent gases and condense the excess water vapour present in them; a Cottrell precipitator for removing the remaining dust in the spent gas before being returned to the main gas line; and a gas storage tank. The briquetting equipment consists of a set of rolls for compressing the hot sponge iron into suitable size briquettes, and conveyors for dewatering the briquettes and discharging them into the product bins.

The ore will be charged in the top of the Herreshoff furnace and will move continuously downward through the furnace, dropping from one hearth to the next. Ore movement on each hearth will be accomplished by means of blades attached to rabble arms revolving horizontally. As the ore descends through the furnace, the moisture will be driven off and the ore heated to the desired temperature by means of the sensible heat in the up-rising stream of reducing gas. On the lower hearths the iron oxide in the ore will be reduced to metallic iron by means of the hydrogen component of the reducing gas, i.e., the preheated coke oven gas entering the bottom of the furnace. The hot sponge iron will be discharged from the bottom hearth of the furnace directly into the briquetting machine, where the material will be compressed into briquettes. This work will be done at low pressures and in a reducing gas atmosphere to prevent re-oxidation of the metallic iron. The briquettes will then be quenched in water and conveyed to the product bins for shipment. The product will contain a small amount or un-reduced iron oxide as it is contemplated to remove only about 90% of the oxygen present in the iron oxide in the ore.

The incoming coke oven gas from the main gas line passes through the desulphurizing units, where the sulphur will be reduced to a few grains per hundred

cubic feet, and then through the heat exchanger and pre-heater will then enter the bottom of the Herreshoff furnace, will reduce the iron oxide to metallic iron on the lower hearths and will pre-heat the ore on the upper hearths. Upon leaving the top of the furnace, the spent gas will pass through the heat exchanger, the gas washer and the Cottrell precipitator and thence to the gas storage tank from which it will be returned to the main gas line leading to the steel mills, where the gas will be used for combustion purposes.

The sponge iron product, containing approximately 88.5% iron, will be shipped to the Republic Steel Corporation's steel plant at Canton, Ohio, where it will be charged as scrap to the electric furnaces. These furnaces require an appreciable tonnage of low carbon scrap free from contamination with alloys, and it is anticipated that these sponge iron briquettes will satisfactorily replace part of the normal scrap charge and thus tend to alleviate, in a small way, the present acute shortage of clean scrap.

Summarizing, this project constitutes a large scale experimental operation for the production of sponge iron and has four distinct factors in its favour: (1) a very high-grade iron ore as furnace feed, (2) a very desirable fuel in the form of coke oven gas, high in hydrogen and low in sulphur, (3) a critical shortage of desirable scrap, thus making the cost of production more of a secondary consideration, and (4) the utilization of the sponge iron product in electric melting furnaces producing a high-grade alloy-free steel that is essential in the war effort." (J. J. Craig; Amer. Gas. Assoc. Monthly, 1943, 25, 4, 147.)

Unfortunately serious technical difficulties have interfered with the successful operation of this furnace. These difficulties are largely connected with the tendency of reduced iron particles to weld at the temperatures usual in low temperature reduction. The effects of such welding have been referred to above (p. 3). Just such effects have been encountered in the operation of the Brassert-Cape furnace, with the result that work at Warren has been abandoned. Even the relatively gentle pressure of rabbles on reduced iron is sufficient to cause its agglomeration.

The **By-Product Oven** was adapted to the reduction of iron ores and concentrates by means of solid reducers, e.g., wood wastes, charcoal, coke, etc., by W. H. Smith of Detroit, who, in the early 30's, operated with some success a plant consisting of five ovens, each of which was capable of producing ten tons of sponge iron per day. Each oven was in essence a shaft furnace, rectangular in plan (10″ wide by 15′ long) and in vertical cross-section (10″ wide and 16′ high). In each oven the shaft was divided into three zones. The upper zone, constructed of boiler plate, formed the pre-heating chamber; the centre zone, the walls of which were built of carborundum brick, formed the reducing chamber; the lower one, fabricated of channel formed the cooling chamber. During its passage through the centre zone, the charge was maintained at a reasonably constant temperature, auxiliary heat being supplied thereto by the combustion of oil in flues situated between the ovens. So-called "equalizers" or "equalizing chambers," were interposed between the flues and the ovens. These equalizers served (1) to maintain uniformity of temperature within the ovens and (2) to prevent the temperature of the ovens from exceeding about 1700°F. The major portion of the heat required for reduction, which is an endothermic process, was supplied by the waste gases formed in the reducing zone—the oil burners merely provided auxiliary heat, as mentioned above.

The charge of iron ore and reducing material was introduced into the ovens by means of hoppers. It moved downward through the ovens under the action

of gravity. The column of material in each oven was supported on a plate at the bottom of the furnace. This plate was moved slowly and constantly back and forth in a direction at right angles to the longitudinal axis of the oven. Between the bottom of the cooling chamber and the plate a space of a few inches was allowed through which the reduced ore fell from the furnace. The continuous discharge of reduced iron through this space ensured the descent of the charge. The rate of descent of the charge was in the neighbourhood of 1 foot per hour. Constant movement of the charge was found essential to prevent welding of the reduced material to the furnace walls.

By the time the charge of ore and reducer had reached the centre zone in the furnace it had attained the temperature of reduction. This temperature varied somewhat according to the ores being reduced. Naturally the charge was held at the reduction temperature, i.e., within the centre zone of the oven, for about one and a half hours. When reduction was complete the charge descended through the lower zone, i.e., the cooling zone, where it was cooled by means of air or water. When air was used as the cooling agent the hot air resulting from cooling was used in the combustion flues. Where water was used for cooling the heated water was used in steam boilers.

In the Smith process an excess of reducer was ordinarily employed. On this account the products of reduction were passed over a magnetic drum concentrator to remove the unburned carbon. This unburned carbon was returned to the furnace as part of the reducer for a fresh charge of ore.

It is of interest to note that Smith supported the view that beneficiation of iron was accomplished more readily **after** the reduction of the iron than before. In some opinions this still remains to be proved.

The finely divided sponge iron obtained from the magnetic separation was briquetted. It could be used in this form or could be sintered at about 2000°F if it had to be shipped any great distance.

Smith, in his ovens at Detroit, was using high-grade ore. The briquettes he obtained had an average content of 99%Fe, with less than 0.5%C.

Of processes involving the use of a **Shaft Furnace** the Wiberg is apparently the most successful. A full description of the Wiberg process recently appeared in "Iron Age" (Swedish Sponge Iron—Einer Ameen, Iron Age, 1944, 153, pp. 55-59, 150 (January 20th, 1944) pp. 56-65 (January 27th, 1944). In view of the availability of information regarding this process it is unnecessary to give details of it here. The fundamental idea behind this process is as follows—"Sintered or lumpy ore, high in iron, is charged into a shaft furnace or other type on the counter-flow principal. In the lower part of the shaft carbon monoxide is introduced at the temperature of 1650-1830°F. While passing through the shaft the gas reduces the ore to iron and in the process the carbon dioxide in the gas rises to 25-30%—corresponding approximately to the equilibrium existing at 1630-1830°F between C, Fe, CO_2 and CO. About 75% of the gas thus formed is evacuated from the shaft by means of a fan and is forced thoough a carburetor where the CO_2, in passing through an incandescent layer of carbonaceous material, is converted into carbon monoxide, which is again introduced into the lower part of the shaft. Since the reaction $CO_2 + C = 200$ is endothermic, heat must be supplied to the carburetor. This is done electrically.

That portion of the gas (about 25%) not circulating through the carburetor continuously causes a pre-reduction of the ore, whereby the CO_2 contents of

the gas is further increased. The carbon monoxide still remaining in the gas is finally burned in the upper part of the shaft where air is introduced, thereby preheating the ore to 1650-1830°F. As an excess of air is used in the preheating zone the ore is partially oxidized. Simultaneously a partial elimination of sulphur takes place.

The lower part of the shaft is designed to form a cooling chamber in which the sponge iron is cooled and finally discharged." (ibid).

It is suggested that the attempt be made to adapt a **furnace of somewhat novel design** to meet Ontario conditions. The plan is to combine features of certain types of Hearth Roaster and of the straight-line By-Product Oven in one unit. Using an oven of about the same dimensions as the Smith furnace it would be fitted it with a series of, say, 16 ft. long straight-line slightly sloping (from centre line to edges) hearths, set one above the other. The top hearth would be charged from above with powdered ore or concentrates. Communication between this hearth and the next would be provided by two parallel slits extending the full lengths of both sides of the hearth. Through these slits the charge would drop onto the second hearth, the charge being caused to move from the centre to the sides of the top hearth by continously vibrating the hearth. The second slightly sloping (from edges to centre line) hearth would be provided with a single slit extending the full length of the longitudinal axis of the hearth. Through this slit the charge would be directed to the third hearth and so on downwards, the positions of the slits in the hearths alternately changing from the centres to the outsides of the hearths. In short, each reducing unit would consist of a series of chambers about 16 feet long, of sufficient height to allow the charge to progress down each hearth under the action of vibration and from 12 to 14 inches wide. These chambers would be set one above the other and through them the charge would be made to progress slowly under the action (1) of vibration, and (2) of gravity. The first three or four of these chambers would serve as pre-heating chambers, in the next few reduction would be completed as the charge descended, while the bottom three or four chambers would serve as cooling chambers.

If electrolytic hydrogen were used as reducer, reduction would be brought about by introducing the pre-heated gas into the lowest of the reduction chambers. The hydrogen would pass over and through the descending charge. Most of the water vapour and such excess hydrogen as remained after reduction would be drawn from the system at the top of the reduction zone, passed through the gas washer to condense the water vapour and thence to the pre-heater where it would join the main supply of hydrogen. Enroute to the gas washer most of the sensible heat in the hydrogen and water vapour would pass to the cell room, where it would be electrolyzed to provide more hydrogen. It would, of course, not be the only source of distilled water. Until such time as a use was found for oxygen the latter would go to waste. New uses for oxygen in the steel industry are now being investigated.

The main advantage of using a furnace of the above design would lie in its simplicity. The reduction zone could be built of refractory bricks of standard design, which, when worn, could be replaced readily. The pre-heating and cooling sections could be built in part of refractory brick and in part of steel (plate and section). New units could be erected alongside old units; certain of the refractory walls could, with advantage, be made common to adjacent units as plant expansion was called for. The erection of such furnaces right on ore properties should not be difficult.

Another advantage of the above type of furnace lies in its adaptability to the treatment of finely-divided ore or concentrates. In this respect it is similar to the Brassert-Cape furnace, which also can accommodate finely-divided ores or concentrates.

Yet another advantage of the above type of furnace is that it could be used, when desired, for the reduction of ores and concentrates by means of solid reducers, indirectly as in the Brassert-Cape (producer gas) and Wiberg (carburetted CO_2) processes. In this case part of the gases resulting from reduction would be extracted from the system at the top of the reduction zone and passed either to a washer, etc. (Brassert-Cape) or to a carburetor to be transformed into carbon monoxide (Wiberg). In essence, the furnace would become a shaft furnace.

As an experimental unit this furnace, because of its versatility, seems to have great possibilities. Even as a production unit it seems to offer some advantages over previous designs. It should be noted that the heat of reduction would be supplied, as in the Brassert-Cape and Wiberg processes, by means of a gaseous reducer pre-heated to 1650-1830°F. The main theme is that the furnace operator in Ontario should aim at being, as far as possible, independent both of solid reducer and solid fuel. It is not the writer's intention to discount the value of carbonaceous materials both as solid reducers and as sources of reducing gases. There is absolutely no reason why consideration should not be given to the use of the wastes of our forests resources, nor to overlook the importance of coal and coke in this connection. Two points should be noted, (1) that a very versatile furnace is available for investigation and for probable reduction of sponge iron, and (2) that, if Ontario is to be **entirely** independent of the outside world it has at least 4 sources of reducer and fuel.

1. All electric—
   (a) Reducer—pre-heated electrolytic hydrogen.
   Fuel—electrical energy supplied to pre-heater.
2. Part electric—
   (a) Reducer—producer gas made from waste forest products.
   Fuel—electrical energy supplied to pre-heater.
   (b) Reducer—carbon monoxide made from waste forest products in electrically heated carbureter.
   Fuel—electrical energy supplied to pre-heater.
   (c) Reducer—Solid waste forest products.
   Fuel—electrical energy applied externally to furnace as, for example, in Smith process.

The use of lignite in conjunction with, or in place of, waste forest products may merit consideration.

It will be clear that, before any large scale operations were started a thorough investigation of the probable cost of producing electroyltic hydrogen on the above scale would have to be made. Dr. Westman of the Ontario Research Foundation has estimated that "For a 3 MM per day capacity plant, operating cells at 2.0 volts and 100 per cent. load factor, the cost exclusive of power was 15.3c/M of total gas; the power cost was equal to the other costs when the a.c. power rate was 0.16c per kilowatt-hour (10.5 $/h.p. yr.) and was twice the other costs when the a.c. power rate was 0.32c per kilowatt-hour (20.9 $/h.p. yr.)." These

figures (1930) may require some modification in the light of more recent available information on the subject.

At the same time it is suggested that a small furnace (10 tons Fe/24 hours) be erected of the design suggested above to test out its value as a reducing unit. At first it might be operated on the Wiberg principle, i.e., in conjunction with a carburetor using charcoal as the source of carbon monoxide. Without altering its design in any way the same furnace might later be employed in conjunction with other devices for the production of reducing gas. If necessary, the furnace could be designed initially to allow of its use, when necessary, as a reducer of concentrates with solid reducers. This would involve external heating of the reducing chambers by electrical or other means (vide Smith process).

To sum up, it is suggested (1) that an investigation of the economics of using electrolytic hydrogen as a reducer be undertaken, and (2) that a small pilot plant of novel design, adaptable to various processes, be erected and used in the semi-commercial reduction of Ontario ores and concentrates.

RECOMMENDED PROJECTS—MINES, MINERALS AND METALLURGICAL RESEARCH, 1947-48

Title	Agency	Capital	Operating	Total
Iron Ores	Ontario Research Foundation	$10,000.00	$16,000.00	$24,000.00
Cable Research	Ontario Research Foundation	2,000.00	18,000.00	20,000.00
Unclassified as yet				56,000.00
				$100,000.00